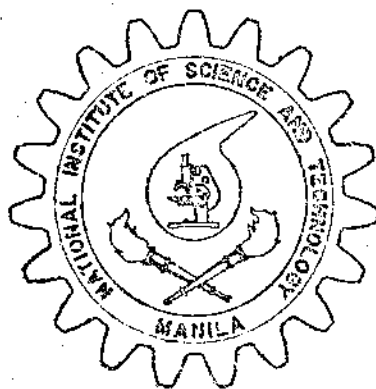


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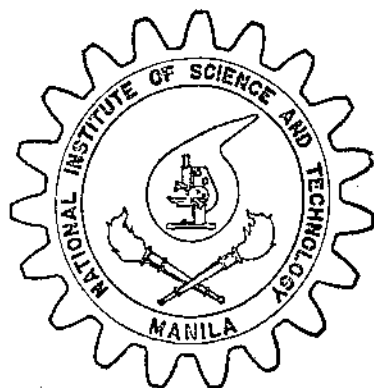
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SCREENING OF PLANTS FROM THE MAKILING AREA FOR ANTIMICROBIAL SUBSTANCES *

By VICTORIA A. MASILUÑGAN, CECILIA V. KALAW
and FLEUR DE LIS C. MASILUÑGAN

National Institute of Science and Technology, Manila

In a previous articles reporting the results of screening of 367 Philippine higher plants for antibacterial substances Masiluñgan, et al.(1,2) used *Micrococcus pyogenes* var. *aureus* Zopf. and *Escherichia coli* (Migula) Castellani and Chalmers as test organisms, and in another paper covering a report on the investigation of 45 species of plants for antitubercular antibiotics, Masiluñgan, et al.(4) used *Mycobacterium tuberculosis* 607 as test bacterium. In the present article the authors report the results of two years (1958-1960) of work using not only the bacteria mentioned above, but also *Fusarium moniliforme* Sheldon as test microorganism.

MATERIALS AND METHODS

The leaves of plants used in this study were obtained from the campus of the College of Agriculture and College of Forestry, Los Baños, Laguna Province. The procedure followed for collecting and sampling of plant specimens, preparing and assaying the aqueous and alcoholic extracts for the presence of antimicrobial substances and measuring zones of inhibition of test microorganisms was as described by Masiluñgan, et al.(2,3)

RESULTS AND DISCUSSIONS

Table 1 shows responses of test microorganism *M. aureus*, *E. coli*, *F. moniliforme*, and *M. tuberculosis* 607 to the anta-

* A project of the Medical Research Center, National Institute of Science and Technology, assisted by National Science Development Board, Projects 2.2, 2.3, and 2.7.



TABLE 1.—Results of antimicrobial tests.*

Plant ^b		Mean halo diameter of triplicate in mm.							
Scientific name	Local name	Alcoholic extract				Aqueous extract			
		<i>M. aureus</i>	<i>E. coli</i>	<i>F. moni- liforme</i>	<i>M. tuber- culosis</i> 607	<i>M. aureus</i>	<i>E. coli</i>	<i>F. moni- liforme</i>	<i>M. tuber- culosis</i> 607
SCHIZAEACEAE:									
<i>Lygodium circinnatum</i> (Burrm.) Swartz	Nito	0	0	0	0	0	0	0	0
CYCARACEAE:									
<i>Cycas revoluta</i> Thunb.	Oliba	0	0	0	0	0	0	0	0
TAXACEAE:									
<i>Podocarpus philippinensis</i> Fosw.	Malakawayan	0	0	0	0	0	0	0	0
HYDROCHARITACEAE:									
<i>Ottelia alismoides</i> (Linn.) Pers.	Kalabua	0	0	** 18.6	0	0	0	0	0
GRAMINEAE:									
<i>Coix lachryma-jobi</i> Linn.	Adlai	0	0	0	0	0	0	0	0
<i>Cymbopogon citratus</i> (DC) Stapl.	Tanglad	* 13.5	0	0	0	0	0	0	0
<i>Cynodon dactylon</i> (Linn.) Pers.	Kawad-kawaran	0	0	0	0	** 19.0	0	0	0
<i>Eleusine indica</i> (Linn.) Gaertn.	Paragis	0	0	0	0	0	0	0	0
<i>Schizostachyon zollingeri</i> Melure	Yellow bamboo	0	0	0	0	** 18.3	0	0	0
<i>Zea mays</i> Linn.	Mais	0	0	0	0	0	** 19.0	* 13.6	0
PALMEAE:									
<i>Arenga pinnata</i> (Wurm.) Merr.	Kaong	0	0	0	0	0	0	0	0
<i>Corypha elata</i> Roxb.	Buri	0	0	0	0	* 14.5	0	0	0
<i>Licuala grandis</i> Wendl.	Bienala	0	0	* 13.8	0	** 20.0	** 14.3	0	0
<i>Licuala spirose</i> Wurm.	Belatbat	0	0	0	* 13.5	0	0	0	0
<i>Ptychosperma macarthurii</i> H. Wendl.	McArthur palm	0	0	0	0	0	0	0	0
ARACEAE:									
<i>Cyrtosperma merkusii</i> (Hassk.) Schott	Palanan	0	0	0	0	** 14.5	0	0	0
<i>Homalomena philippinensis</i> Engl.	Payau	* 14.0	0	0	0	0	0	0	0
<i>Pistia stratiotes</i> Linn.	Kinpo	0	0	0	0	0	0	0	0

PONTEDERIACEÆ:									
<i>Monochoria</i>	<i>raginialis</i>	Kalabua	0	0	0	0	0	0	0
(Burn. L.) Presl.									
MUSACEÆ:									
<i>Heliconia platystachys</i> Baker	Falest bird of paradise	0	0	0	0	0	0	0	0
<i>Musa errans</i> (Blanco) Teodoro var. <i>bolosan</i> Teodoro	Butuan	0	0	0	0	0	0	0	0
ZINGIBERACEÆ:									
<i>Costus speciosus</i> (Koenig) Sm.	Setawar	0	0	0	0	0	0	0	0
<i>Curcuma icnga</i> Linn.	Dilsu	0	0	0	0	0	0	0	0
<i>Hedyctium philippinense</i> K. Schum.	Tagbak	* 13.7	** 13.6	0	0	0	0	0	0
ORCHIDACEÆ:									
<i>Spathoglottis plicata</i> Blume	Ground orchid	* 13.5	0	0	0	0	0	0	0
<i>Vanilla planifolia</i> Ait.	Vanilla	* 13.7	0	0	0	* 13.5	0	0	0
MORACEÆ:									
<i>Artocarpus heterophyllus</i> Lam.	Lanka	0	*** 14.3	0	0	* 13.6	0	0	0
<i>Artocarpus odoratissima</i> Blanco	Marang	0	0	0	0	*** 17.3	0	0	0
<i>Artocarpus rigida</i> Blume	Monkey jack fruit	0	0	0	0	*** 15.0	0	0	0
<i>Ficus bentamina</i> Linn.	Balete	0	0	0	0	0	0	*** 38.0	0
<i>Ficus stipulosa</i> Miq.	Botgo	0	0	0	0	0	0	0	0
<i>Ficus variegata</i> Blume	Tangisang-buayauak	* 14.0	0	0	0	0	0	0	0
<i>Streblus asper</i> Lour.	Kalios	0	0	0	0	0	0	0	0
NYCTAGINACEÆ:									
<i>Pisonia alba</i> Spanoghe	Maluko	0	0	0	0	0	0	0	0
PORTULACACEÆ:									
<i>Portulaca oleracea</i> Linn.	Olasiman	0	0	** 14.5	0	* 14.0	** 14.0	0	0
MAGNOLIACEÆ:									
<i>Mitchella alba</i> DC.	Champakang puti	0	0	0	0	* 14.5	0	0	0
<i>Mitchella champaka</i> Linn.	Champakang pula	0	0	0	0	* 13.5	0	0	0
ANONACEÆ:									
<i>Annona muricata</i> Linn.	Guayabano	0	0	** 14.0	0	*** 18.0	*** 16.0	0	* 13.5
<i>Artabotrys swarcuensis</i> Blume	Susong-kidabau	*** 17.3	** 17.0	0	0	** 19.3	** 15.0	0	0
LAURACEÆ:									
<i>Cinnamomum camphora</i> (L.) to Nees and Eberm.	Camphor	* 13.5	0	0	0	* 13.5	0	0	0
<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	Pusa-puso	0	0	0	0	0	0	0	0
LEGUMINOSÆ:									
<i>Adenanthera parsonia</i> Linn.	Saga hutan	0	0	0	0	0	0	0	0
<i>Arachis hypogaea</i> Linn.	Mani	0	0	0	0	0	0	0	0
<i>Bauhinia acuminata</i> Linn.	Alibang-bang	0	0	0	0	0	0	0	0
<i>Caesalpinia coriaria</i> (Jacq.) Willd.	Dividivi	*** 25.3	0	0	0	*** 18.6	0	0	0
<i>Cassia alata</i> Linn.	Akapulko	0	0	0	** 16.5	*** 21.3	0	0	0
<i>Centrosema pubescens</i> Benth.	Centrosema	0	0	0	* 14.0	0	0	0	0
<i>Desmodium tortuosum</i> (Sw.) DC.		0	0	0	0	0	0	0	0
<i>Dolichos lablab</i> Linn.	Batau	0	0	0	0	0	0	0	0
		0	0	0	* 13.5	*** 18.3	** 14.3	0	0

TABLE 1.—Result of antimicrobial tests *—Continued.

Plant ^b		Mean halo diameter of triplicate in mm.							
Scientific name	Local name	Alcoholic extract				Aqueous extract			
		<i>M. aureus</i>	<i>E. coli</i>	<i>F. moniliforme</i>	<i>M. tuberculosis</i> 307	<i>M. aureus</i>	<i>E. coli</i>	<i>F. moniliforme</i>	<i>M. tuberculosis</i> 607
<i>Entada phascoloides</i> (Linn.) Merr.	Gogo	0	0	0	0	** 14.0	0	0	0
<i>Haematoxylon campechianum</i> Linn.	Logwood	** 18	0	0	0	** 18.0	0	0	0
<i>Inocarpus edulis</i> Forst.	Kayam	0	0	0	0	0	* 13.5	0	0
<i>Mucuna pruriens</i> (Linn.) DC.	Nipai	0	0	0	0	** 20.5	0	0	0
<i>Peltophorum inerme</i> (Roxb.) Llanos	Siar	*** 16.3	** 16.5	0	0	** 14.0	* 13.5	0	0
<i>Phaseolus lunatus</i> Linn.	Patani	0	0	0	* 14.0	** 20.0	0	0	0
<i>Pterocarpus indicus</i> Willd.	Narra	0	0	0	0	0	0	0	0
OXALIDACEAE:									
<i>Averrhoa bilimbi</i> Linn.	Kanias	0	0	0	* 14.0	** 17.0	** 14.3	0	0
<i>Biophytum sensitivum</i> (Linn.) DC.	Makahiang-lalaki	0	0	0	0	0	0	0	0
<i>Oxalis repens</i> Thunb.	Taingan-daga	0	0	0	0	0	0	0	0
ERYTHROXYLACEAE:									
<i>Erythroxylum coca</i> Lam.	Coca	* 14.0	* 13.5	0	0	0	0	0	0
RUTACEAE:									
<i>Atalantia citroides</i> Correa	Atalantia	0	0	0	0	0	0	0	0
<i>Citrus hystrix</i> DC.	Kabuyau	0	0	0	0	* 13.5	0	0	0
<i>Citrus maxima</i> (Burm.) Merr.	Lukban	0	0	0	0	** 19.0	0	0	0
<i>Citrus microcarpa</i> Bunge	Kalamansi	0	0	* 13.6	0	0	0	0	* 13.6
<i>Citrus nobilis</i> Lour.	Naranjita	* 13.5	* 13.5	0	0	** 16.0	** 13.5	0	0
<i>Triphasia trifolia</i> (Burm. f.) P. Wils.	Limoncito	* 13.6	0	0	* 14.3	0	0	0	0
SIMARUBACEAE:									
<i>Quassia amara</i> Linn.	Coralis	*** 19.6	0	0	0	* 15.0	0	0	0
BURSERACEAE:									
<i>Cavendishia asperum</i> Benth.	Fagsahingin	*** 21.7	0	0	0	** 20.3	0	0	0
<i>Forma villosum</i> Lam.									
MALPHIGIACEAE:									
<i>Thryallis glauca</i> (Cav.) O. Ktze.	Cuisia	* 14.0	0	0	0	0	0	0	* 15.0
EUPHORBIACEAE:									
<i>Aleurites fordii</i> Hengl.	Tong oil	* 13.5	0	0	0	0	0	0	0

<i>Alseodaphne moluccana</i> (Linn.) Willd.	Lumbang-bato	0	0	0	0	0	0	0	0
<i>Antidesma pentandra</i> Merr.	Signal-pugo	*** 12.0	0	0	0	0	0	0	* 14.0
<i>Breynia microa</i> (Bull.) Small									0
var. <i>rescopida</i> Hort.	Snow hush	0	0	0	0	*** 18.3	*** 15.0	*** 14.3	0
<i>Breynia rhamnoides</i> (Retz.) Muell.-Arg.									
	Matang-hipon	0	0	0	0	0	0	0	0
<i>Euphorbia pilulifera</i> Linn.	Gatas-gatas	*** 18.0	0	0	0	0	0	0	0
<i>Hura crepitans</i> L.	Sand box tree	*** 13.0	0	0	0	0	0	0	0
<i>Mallotus philippensis</i> (Lam.) Muell.-Arg.					* 16.0	** 15.0	0	0	* 13.6
	Banato	*** 19.3	0	0	*** 24.0	** 19.3	0	0	0
<i>Phyllanthus niruri</i> Linn.	Sampasampalukan	*** 17.5	0	0	* 14.3	* 20.0	0	0	0
<i>Ricinus communis</i> Linn.	Tangan-tangan	*** 21.0	0	0	0	0	0	0	* 14.3
ANACARDIACEAE:									
<i>Anacardium occidentale</i> Linn.	Kasui	*** 16.6	0	0	0	* 13.5	0	0	* 14.0
SAPINDACEAE:									
<i>Nephelium lappaceum</i> Linn.	Rambutun	*** 20.0	* 13.6	0	0	0	0	0	* 15.0
VITACEAE:									
<i>Cayratia trifolia</i> (Linn.) Quis.	Kalit-kalit	0	0	0	0	0	0	0	0
TILIACEAE:									
<i>Corchorus capsularis</i> Linn.	Pasau-na-bilog	0	0	0	0	0	0	0	0
<i>Diplocladus paniculatus</i> Turcz.	Balubo	0	0	0	0	0	0	0	0
MALVACEAE:									
<i>Hibiscus mutabilis</i> Linn.	Ampola	0	0	0	* 14.0	0	0	0	0
BOMBACEAE:									
<i>Ochroma lagopus</i> (Swartz.) Urb.	Balsa wood	* 13.5	0	0	0	0	0	0	0
GUTTIFERAE:									
<i>Garcinia binucao</i> (Blanco) Choisy	Binukau	* 13.5	0	0	0	0	* 13.5	0	0
FLACOURTIACEAE:									
<i>Hydnocarpus anthelmintica</i> Pierre	Kamupang	0	0	0	0	* 14.0	0	0	0
ELAEAGNACEAE:									
<i>Elaeagnus philippensis</i> Torr.	Alingaro	* 13.5	0	0	0	*** 17.3	0	0	0
LYTHRACEAE:									
<i>Lawsoria inermis</i> Linn.	Sinamomo	** 14.8	0	0	* 16.3	0	0	0	* 15.5
COMMURTEAE:									
<i>Terminalia microcarpa</i> Deene	Kalumpit	* 14.0	* 13.5	0	0	0	* 13.5	0	0
MYRTACEAE:									
<i>Acmena acuminatissima</i> (Blume) Merr. and Perry	Binoluan	* 14.5	0	0	0	** 14.5	*** 17.8	0	0
<i>Eucalyptus corymbosa</i> F. Muell.	Sugar gum	*** 25.33	0	0	*** 27.0	*** 19.6	0	0	* 14.6
<i>Eucalyptus deglupta</i> Blume	Anamanit	*** 20.0	0	0	0	* 14.0	* 13.5	0	0
<i>Melaleuca leucadendron</i> Linn.	Cajapot tree	0	0	0	0	0	0	0	0
<i>Pedium guajava</i> Linn.	Bayabas	*** 15.6	0	0	* 20.0	0	0	0	0

TABLE 1.—Results of antimicrobial tests *—Continued.

Scientific name	Local name	Mean halo diameter of triplicate in mm.							
		Alcoholic extract				Aqueous extract			
		<i>M. aureus</i>	<i>E. coli</i>	<i>F. moniliforme</i>	<i>M. tuberculosis</i> 607	<i>M. aureus</i>	<i>E. coli</i>	<i>F. moniliforme</i>	<i>M. tuberculosis</i> 607
ARALIACEAE:									
<i>Nothopanax fruticosum</i> (Linn.) Miq.	Papua	0	0	0	0	0	0	0	0
<i>Schefflera odorata</i> (Blanco) Merr. and Rolfe	Lima-lima	0	0	0	* 14.0	0	0	0	0
PLUMBAGINACEAE:									
<i>Phonbago indica</i> Linn.	Laurel	0	0	0	0	0	0	0	0
SAPOTACEAE:									
<i>Chrysophyllum oeiliforme</i> Lam.	Caimitillo	0	0	0	0	* 14.5	0	0	0
<i>Manilkara kauki</i> Dubarb.	Bilat-bikat	* 13.5	0	0	0	* 13.5	0	0	0
EUPHORBIACEAE:									
<i>Diospyros discolor</i> Willd.	Mabolo	*** 18.0	0	0	0	0	0	0	0
LOGANIACEAE:									
<i>Strychnos nux-vomica</i> Linn.	Strychnine plant	* 14.0	0	0	0	* 13.5	0	0	0
ASCLEPIADACEAE:									
<i>Asclepias curassavica</i> Linn.	Balak-damo	0	0	0	* 13.5	0	0	0	0
VERBENACEAE:									
<i>Clerodendron quinquevulvum</i> (Blanco) Merr.	Bugauak-na-pula	0	0	0	0	0	0	0	0
<i>Lantana camara</i> Linn.	Coronitas	*** 17.0	0	0	* 13.5	* 13.5	0	0	0
<i>Pilea rotundifolia</i> Linn.	Sand paper vine	0	0	0	0	0	0	0	0
LABIATÆ:									
<i>Hyptis capitata</i> Jacq.	Botonesan	0	0	0	0	0	0	0	0
SOLANACEAE:									
<i>Brusellisia americana</i> Linn.	Brusellisia	* 13.5	0	0	0	0	0	*** 23.3	0
<i>Capsicum frutescens</i> Linn.	Sileng-labuyo	0	0	0	0	*** 16.6	* 13.8	0	0
<i>Capsicum frutescens</i> Linn. var. <i>gracillimum</i> (Linn.) Sendt.	Sileng-bilog	0	0	0	0	*** 15.0	0	0	0
<i>Cestrum parqui</i> L'Hér.	Dama de dia	0	0	0	0	0	0	0	0
<i>Solanum hartwegii</i> N. E.	Golden cup	0	0	0	0	0	0	** 17.0	0
BIGNONIACEAE:									
<i>Kigelia africana</i> (Lam.) Benth.	African sausage tree	0	0	0	0	0	0	0	0

<i>Parmentiera cereifera</i> Seem.	Candle tree	0	0	0	0	0	0	0	0
<i>Parmentiera edulis</i> DC	Candle tree	0	0	0	0	0	0	0	0
ACANTHACEAE:									
<i>Hemigraphis colorata</i> (Blume)									
Hafler I.	Dahong-pula	* 13.5	0	0	0	0	0	0	0
<i>Thunbergia grandiflora</i> Roxb.	Sayflower	0	0	0	0	0	0	0	0
RUBIACEAE:									
<i>Borreria hispida</i> (Linn.) K.									
Schura	Landina	0	0	0	0	0	0	0	0
<i>Coffea robusta</i> Linn.	Robusta coffee	0	0	0	0	** 16.0	0	0	0
<i>Pucleria forata</i> Linn.	Kantoni	0	0	0	0	* 14.0	0	0	0
<i>Posquieria latifolia</i> Roem. and Schult.	Baraja	* 13.5	0	0	0	0	0	0	0
<i>Psychotria lucanensis</i> (Cham. and Schlecht.) F.-Vill.	Tagpong-gubat	** 17.0	* 13.5	0	0	** 21.0	0	0	0
CUCURBITACEAE:									
<i>Momordica charantia</i> Linn.	Ampalaya	* 13.7	* 13.6	0	** 18.0	* 13.6	0	0	0
COMPOSITAE:									
<i>Artemisia vulgaris</i> Linn.	Damong-maria	* 13.5	0	0	0	** 22.0	0	0	0
<i>Chrysanthemum indicum</i> Linn.	Mansanilla	0	0	0	0	** 19.0	0	0	** 21.3
<i>Helianthus annuus</i> Linn.	Mirasol	** 14.0	0	0	0	* 13.6	0	0	0
<i>Tithonia diversifolia</i> A. Gray	Mirasolia	** 17.2	0	0	0	** 16.8	0	0	0
<i>Tridax procumbens</i> Linn.	Coat buttons	0	0	0	0	0	0	0	0

* Activity against test organisms is indicated by *** for complete inhibition; ** for partial inhibition; * for slight indication of inhibition; 0 for no effect. The numbers refer to the diameter of the halo zone in mm.

^b The system of classification is patterned after that of Engler and Prantl.

gonistic action of 129 aqueous and 129 alcoholic extracts prepared from 129 species of plants. Eighty seven out of 129 plants examined or sixty-seven and four tenth per cent of the plants subjected to these tests showed positive evidence of the presence of antimicrobial substances of varied potency.

Alcoholic extracts.—Forty seven exhibited varying degrees of inhibition of *M. aureus*, of which 20 were complete, 3 partial, and 24 slight.

Ten showed varying degrees of inhibition of *E. coli*, of which 1 was complete, 3 partial, and 6 slight.

Five showed varied inhibitory action against *F. moniliforme*, of which 3 were partial and 2 slight.

Eighteen of 127 alcoholic extracts possessed inhibitory properties against *M. tuberculosis* 607, of which 2 were complete, 2 partial, and 14 slight.

Aqueous extracts.—Fifty five showed varying degrees of inhibition of *M. aureus*, of which 29 were complete, 10 partial, and 16 slight.

Sixteen exhibited varied inhibitory properties against *E. coli*, of which 4 were complete, 6 partial, and 6 slight.

Only five produced varying degrees of inhibition to *F. moniliforme*, of which 2 were complete, 2 partial, and 1 slight.

Eleven revealed varying degrees of inhibition to *M. tuberculosis* 607 of which 1 was partial and 10 slight.

In the discussion above it is shown that the substances inhibitory to *M. aureus* and *E. coli* are more readily extractable by water than by alcohol. The antimycobacterial substances are more soluble in alcohol than in water. The active principles extractable from the leaves either by water or alcohol are more inhibitory to *M. aureus* than to *E. coli* and *F. moniliforme*. In their previous article Masilunigan, et al.(4) reported that 46.6 per cent of the alcoholic and 44.4 per cent of the aqueous extracts from medicinal plants locally used for the treatment of tuberculosis were found positive for substances inhibitory to *M. tuberculosis* 607. In the present screening, only 14.6 per cent of the alcoholic and 8.9 per cent of the aqueous extracts inhibit *M. tuberculosis* 607. The high percentage of inhibition shown in the previous paper(4) may indicate that more of these plants locally known to possess cure for tuberculosis contain the curative principles.

Both the alcoholic and aqueous extracts of *Casalpinia coriaria* and *Canarium asperum* fo. *villosum* produced complete and wide

zone of inhibition of *M. aureus*. The alcoholic extracts of *Ricinus communis*, *Nephelium lappaceum*, *Eucalyptus corynocalyx*, and *Eucalyptus deglupta* and the aqueous extracts of *Licuala grandis*, *Mucuna pruriens*, *Phaseolus lunatus*, *Psychotria luconiensis*, and *Artemisia vulgaris* also showed complete wide zone of inhibition to the same organism. Only the alcoholic extract of *Mallotus philippensis* and *Eucalyptus corynocalyx* showed complete broad zone of inhibition of *M. tuberculosis* 607. Aqueous extract of *Artocarpus rigida* and *Brunfelsia americana* showed complete zone of inhibition to *F. moniliforme*.

SUMMARY

1. Aqueous and alcoholic extracts of one hundred twenty-nine species of plants were screened for the presence of substances inhibitory to *Micrococcus aureus*, *Escherichia coli*, *Fusarium moniliforme*, and *Mycobacterium tuberculosis* 607.

2. Of the alcoholic extracts 47 showed varying degrees of inhibition of *M. aureus*, 10 of *E. coli*, 5 of *F. moniliforme*, and 18 of *M. tuberculosis* 607.

3. Fifty five of the aqueous extracts exhibited varying degrees of inhibition to *M. aureus*, 16 to *E. coli*, 5 to *F. moniliforme*, and 11 to *M. tuberculosis* 607.

4. Species having marked antagonistic effect on *M. aureus* are *Licuala grandis*, *Casalpinia coriaria*, *Mucuna pruriens*, *Canarium asperum* fo. *villosum*, *Phaseolus lunatus*, *Ricinus communis*, *Nephelium lappaceum*, *Eucalyptus corynocalyx*, *Eucalyptus deglupta*, *Psychotria luconiensis*, and *Artemisia vulgaris*.

5. *Mallotus philippensis* and *Eucalyptus corynocalyx* possess active principles which are strongly antagonistic to *M. tuberculosis* 607.

6. *Artocarpus rigida* and *Brunfelsia americana* contain potent antifungal substances which have remarkable inhibitory effect on *F. moniliforme*.

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LOSS OF ASCORBIC ACID IN CHEMICALLY PEELED AND CANDIED SANTOL [SANDORICUM KOETJAPE (BURM. F.) MERR.] FRUIT

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A previous study by Soliven, et al.(8) had shown that santol fruit could be peeled chemically with 5 per cent sodium hydroxide solution for the purpose of making santol preserves and candied products. But Lamb, et al.,(6) in a study on the retention of nutrients during the commercial production of various canned fruits and vegetables, had shown the loss of ascorbic acid in lye-peeled Clingstone peaches. Questions have, therefore, been raised as to the amount of the loss or retention of the nutrients, particularly ascorbic acid, in the chemically peeled santol.

In this investigation the purpose of the authors is to determine the extent of loss of ascorbic acid during the chemical-peeling and candying processes of the fruit.

EXPERIMENTAL PROCEDURE

Santol fruits were purchased from the local market. Mature, fresh fruits with thick rind, free from blemishes, were chosen and washed with tap water. Twenty-five fruits were used for all trials. The fruits were blanched in 2 liters of boiling water for 3 minutes. The blanched fruits were immersed in a 5 per cent sodium hydroxide solution for 5 minutes at 93.5°C and then placed immediately under cold running water with which they were washed thoroughly, and the skin scraped off with a stainless steel spatula.

The peeled fruits were quartered, pitted, washed three times in about 2 liters of water and then soaked in a solution containing 0.05 per cent potassium metabisulfite and 0.2 per cent calcium chloride for 2 hours. Stainless steel knives, kettles, and glass bowls were used. The fruits were drained, placed in a muslin bag and immersed in boiling water for 2 minutes, then dried under infrared lamps for 30 minutes at 60°C.

The partially dried fruits were then syrup-treated. Two types of syrup treatment were made: (a) The fruits and 50° Brix syrup were cooked together to boiling, and temperature was maintained at 93.5° to 102°C for 30 minutes. The syrup was drained off, adjusted to 60° Brix, heated to boiling and then poured into the fruits. This mixture was allowed to stand overnight in wide-mouthed glass jars tightly covered with brown paper. This procedure was repeated four times before drying. (b) Hot syrup was added to the chemically peeled fruits and successive soakings in 60° Brix syrup were done as in (a). Two trial runs for each syrup treatment (a) and (b) were made.

Slurries were prepared from the fruit purchased from the market for vitamin C analysis of the fresh fruit. This sample was peeled with a stainless steel knife. The succeeding samples used for ascorbic acid analysis were drawn at different intervals from the various stages of the chemical-peeling and candying processes, i.e., the first sample was representative of the chemically peeled fruits; the second sample was taken after the peeled fruits were soaked in 0.05 per cent potassium metabisulfite and 0.2 per cent calcium chloride for one hour; the third sample was from a two-hour soaking in 0.05 per cent potassium metabisulfite and 0.2 per cent calcium chloride solution; and the fourth sample was taken after one day of syrup treatment.

Sampling was done by slicing off a piece from the quartered fruits taken at random. Proximate and mineral analyses were also done on the chemically peeled and the candied santol.

In all instances, samples for ascorbic-acid analysis were prepared by blending 25 grams of the fruit with 100 ml of 1 per cent oxalic acid in a Waring blender and filtering the puree through coarse filter paper. The filtrate was then assayed by the Bolin and Book modification of the Roe and Osterling colorimetric method.⁽²⁾ Proximate and calcium analyses were determined by the AOAC method;⁽¹⁾ phosphorus, by Lowry and Lopez' modification of the Fiske and Subbarow method;⁽⁷⁾ and iron, by the Hahn method.⁽³⁾

RESULTS AND DISCUSSION

Table 1 shows the loss of ascorbic acid in the chemically peeled and candied santol. The loss was found to occur during chemical-peeling and during the time between chemical-peeling

TABLE 1.—Loss of ascorbic acid in chemically peeled and candied santol fruit.

Treatment of samples	Ascorbic acid content and per cent loss							
	Trial 1		Trial 2		Trial 3		Trial 4	
	Mg/100 gms	Per cent loss	Mg/100 gms	Per cent loss	Mg/100 gms	Per cent loss	Mg/100 gms	Per cent loss
Fresh fruit (edible portion)	10.78		8.75		9.06		10.47	
After chemical-peeling	5.94	44.94	7.19	17.86	6.56	27.59	5.31	49.25
After 1 hour soaking in 0.05 per cent $K_2S_2O_8$ + 0.2 per cent $CaCl_2$	5.44	49.57	5.94	32.14	6.50	28.28	3.75	64.18
After 2 hours soaking in 0.05 per cent $K_2S_2O_8$ + 0.2 per cent $CaCl_2$	3.75	65.22	4.44	49.29	5.25	42.07	3.50	66.57
After blanching and drying	3.50	67.54	2.50	71.43	4.63	48.97	2.88	72.54
After cooking in syrup and soaking for 24 hours in the same syrup	0.00	100.00	0.00	100.00				
After soaking in syrup for 24 hours (w/o cooking) ..					0.00	100.00	0.00	100.00

and syruing. The greatest loss occurred during the chemical-peeling process. Leachings caused by repeated washings after the chemical treatment, vitamin C oxidation due to contact with iron, and exposure to air account for the great loss of ascorbic acid.

There was no definite pattern in the decrease of ascorbic-acid content, although, a downward trend was evident. All the trials showed complete loss of ascorbic acid after the first day of syrup treatment. The varying percentage loss of ascorbic acid observed in the different trials could possibly be due to sampling since obtaining a representative sample was rather difficult. Holman(4) states that the problem of satisfactory sampling is usually encountered in fruits and vegetables since the size of the sample taken is small when compared with that of the whole tissue being examined. He also reports that when oranges were cut longitudinally into quarters and the quarters analyzed separately, there were differences in ascorbic-acid concentration in both peel and juice between one quarter and another.

The results of the proximate and mineral analyses are shown in Table 2. Although the values obtained for the candied fruit are lower than those obtained for the chemically peeled sample, the retention of nutrients in the end-product is evident.

TABLE 2.—*Proximate composition and mineral contents of chemically peeled and candied santol fruit. (Values per 100-gram edible portion, moisture-free basis.)*

Nutrient	Chemically peeled fruit *	Candied fruit *
Protein, grams	2.4	1.0
Fat, grams	10.4	2.8
Ash, grams	3.2	0.5
Carbohydrate (by difference), grams	84.0	95.7
Calcium, milligrams	384.0	199.0
Phosphorus, milligrams	144.0	18.0
Iron, milligrams	6.4	1.3

* Moisture content, 87.5 grams

** Moisture content, 7.0 grams

Decreases in mineral content may have occurred during the different stages of processing of the candied fruit. Kramer and Smith(5) report that the ash and phosphorus contents of vegetables generally decrease during processing. Decrease in moisture content is due to drying.

SUMMARY AND CONCLUSION

Santol [*Sandoricum koetjape* (Burm. f.) Merr.] fruits were peeled by immersing them in a 5 per cent sodium hydroxide solution at 93.5°C for 5 minutes. The peeled fruits were syrup-treated and then dried. The fresh fruits were analyzed for vitamin C content. Other samples used for vitamin C analyses were drawn at different intervals from the various stages of the chemical-peeling and candying processes. Proximate and mineral analyses of the chemically peeled and candied santol fruits were made. The study showed complete loss of ascorbic acid after soaking for a day in syrup with or without the application of heat. However, other nutrients, like calcium, phosphorus and iron, were still present in the finished product.

The investigation showed a complete disappearance of ascorbic acid in the candied santol fruits. However, other nutrients like calcium, phosphorus and iron may still be derived from it, aside from its being a good source of energy.

In view of the above results, future studies of candied santol fruits will be made with particular emphasis on the development of a process which would minimize the loss of these nutrients in the said products and would fortify the same with ascorbic acid.

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A SEMI-EMPIRICAL EQUATION FOR THE THERMAL NEUTRON DISTRIBUTION OF PRR-I

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TWO TEXT FIGURES

A readily available and workable equation for the energy distribution of thermalized neutrons in the core of PRR-I is very useful for many types of calculations specially when digital machine calculators are lacking. As a first approximation, a hardened Maxwellian distribution has been used; however, better results can be obtained if a corrected Maxwellian distribution is available. In this report, the SOFOCATE energy distribution for a Wigner-Wilkins model of neutron slowing-down process was assumed to represent the true neutron distribution in PRR-I and a semi-empirical equation was fitted to this distribution.¹

PROCEDURE

A hardened Maxwellian equation of the form

$$N(E)_{\text{Maxwellian}} = C N E^{1/2} \exp. (-E/E_T) \quad (1)$$

where $N(E)$ = number of neutrons with energies E to $(E + dE)$ per unit volume

E_T = the most probable neutron energy
= 0.0309 ev

C = arbitrary constant needed to make $N(E_T)_{\text{Maxwellian}}$ equal to $N(E_T)_{\text{SOFOCATE}}$

N = total number of neutrons in the core fulfilling a Maxwellian distribution

was used as a first approximation. The differences between the SOFOCATE values of the neutron density $N(E)_{\text{SO}}$ and the values of $N(E)_{\text{Maxwellian}}$ computed from equation (1) were calculated at energies from 0.00015 to 0.625 ev, the thermal group range. Here 0.00015 ev can be considered almost equal to zero. These differences were plotted against their corresponding energies as shown in Fig. 1. It is seen that

¹Juliano, J. O., Philip. Jour. Sci. 91 (1962) 381-392.

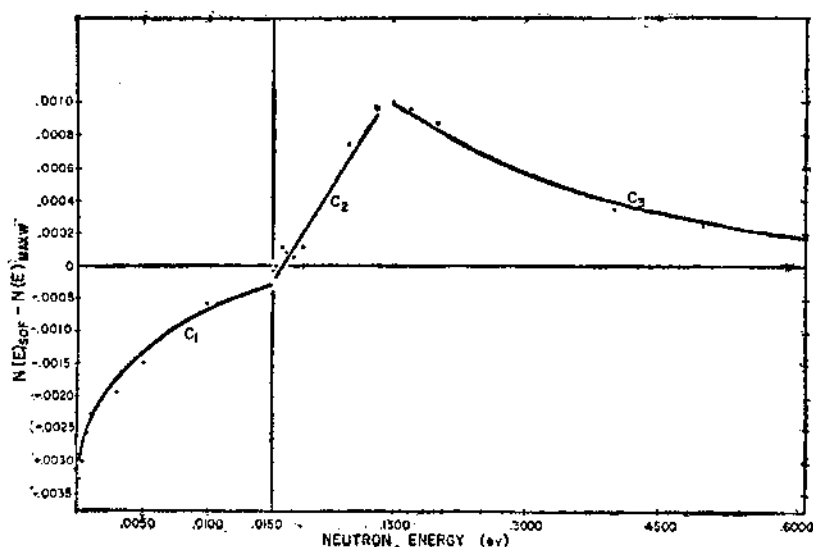


FIG. 1. 'SOFOCATE'—pure Maxwellian neutron distribution differences.

these correction values can be grouped into three regions, namely:

Group number	Energy range	Type of correction
Group I	0.00015 — 0.016 ev	parabolic curve
II	0.016 — 0.15 ev	straight line
III	0.15 — 0.625 ev	exponential curve

The fitted neutron distribution therefore becomes

$$N(E) = N(E)_{\text{maxwellian}} + N(E)_{\text{correction}}$$

$$\text{where } N(E)_{\text{correction}} = - (313 - 29 \sqrt{6958E} - 1) \times 10^{-5} = C_1 \quad (2)$$

for $0.00015 \leq E \leq 0.016$ ev

$$N(E)_{\text{correction}} = 0.00861E - 0.00021 = C_2$$

for $.016 \leq E \leq .15$ ev

$$N(E)_{\text{correction}} = 0.00175 \exp(-3.70E) = C_3$$

for $0.15 \text{ ev} \leq E \leq 0.625$ ev

A comparison between the SOFOCATE neutron-density values and those obtained from eq. (2) showed negligible differences. These are given in Table 1 below and in Fig. 2.

TABLE 1.—Comparison between the "SOFOCATE" and calculated neutron distributions.

E	N(E) Maxwellian	N(E) SOFOCATE	(NE) Correction	N(E) Maxwellian + correction	Difference	Error
(<i>cc.</i>)						<i>Per cent</i>
0.0005	858	558	-267	581	-23	4.1
0.0010	1195	967	-242	953	+14	1.4
0.0030	1940	1744	-183	1757	-13	0.7
0.0050	2347	2198	-143	2204	-6	0.3
0.0070	2603	2497	-111	2492	+5	0.2
0.0100	2823	2767	-56	2755	+12	0.4
0.0150	2941	2936	-26	2915	+21	0.7
0.0160	2941	2941	0	2941	0	0.0
0.0200	2889	2901	+2	2901	0	0.0
0.0300	2560	2569	+4	2564	+5	0.2
0.0500	1730	1742	+22	1752	-10	0.6
0.0700	1072	1109	+39	1111	-2	0.2
0.1000	485	561	+65	550	+11	2.0
0.1300	210	306	+91	301	+5	1.6
0.1500	118	218	+100	218	0	0.0
0.1700	66	163	+93	159	+4	2.5
0.2000	27	115	+84	111	+4	3.5
0.3000	1	56	+54	55	+1	1.8
0.4000	0	36	+40	40	-4	11.1
0.5000	0	26	+28	28	-2	7.7
0.6000	0	20	+19	19	+1	5.0
0.6200	0	19	+18	18	+1	5.3

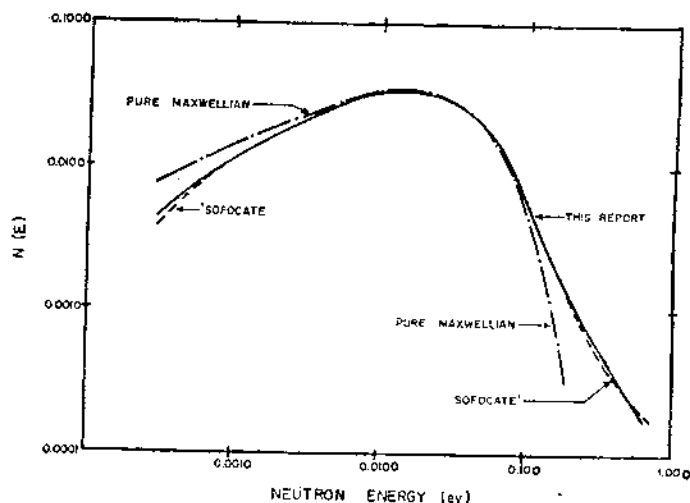


FIG. 2. Thermal neutron distribution in PRR-I core.

RESULTS

The accuracy and closeness of the fit was tested by comparing the IBM effective cross section results as given by the SOFOCATE code with the hand-calculated effective cross section using equation (2). The specific cross section used was that of a $1/v$ absorber whose cross section was assumed to be unity at 2200 m/sec and whose IBM effective thermal-group cross section was 0.6638 barns.²

² Ibid.

From equation (2) the effective cross section in the thermal energy range is

$$\begin{aligned}\bar{\sigma} &= \frac{\int_0^{0.625 \text{ ev}} \sigma(E) \phi(E) dE}{\int_0^{0.625} \phi(E) dE} = \sigma_0 \sqrt{E_0} \frac{\int_0^{0.625} N(E) dE}{\int_0^{0.625} N(E) E^{1/2} dE} \\ &= \sigma_0 \sqrt{E_0} \left(\frac{\int_0^{0.625} 0.3902 E^{-32.363E} dE + \int_{0.00015}^{0.016} c_1 dE + \int_{0.016}^{0.15} c_2 dE + \int_{0.15}^{0.625} c_3 dE}{\int_0^{0.625 \text{ ev}} 0.3902 E e^{-32.363E} dE + \int_{0.00015}^{0.016} c_1 E^{1/2} dE + \int_{0.016}^{0.15} c_2 E^{1/2} dE + \int_{0.15}^{0.625} c_3 E^{1/2} dE} \right) \\ &= 0.6696 \text{ barns.}\end{aligned}$$

The percentage difference between the SOFOCATE value of 0.6638 barns and the calculated value for this report of 0.6696 barns is only 0.87 per cent.

The average speed v of the neutrons in the thermal group was calculated from

$$\bar{v} = \frac{\int_0^{v_1} N(v) v dv}{\int_0^{v_1} N(v) dv} = 3.286 \times 10^5 \text{ cm/sec.}$$

where v_1 is the speed of neutrons at 0.625 ev = 8.625×10^5 cm/sec.

CONCLUSION

The neutron-distribution function for the thermal group as presented in this report when used in the PRR-I core physics calculations should give results comparable in accuracy to digital calculating machine values.

CALIBRATION OF COBALT-60 TELETHERAPY MACHINES USING BENZENE-IN-WATER DOSIMETERS

BY JOSE O. JULIANO and GLORIA R. CAPCO
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FOUR TEXT FIGURES

Recent developments have indicated the growing importance of Co-60 teletherapy machines as a medical tool in the Philippines. In this connection an efficient, simple, reliable and inexpensive method of radiation measurement is warranted to safeguard the public and to give the radiotherapists precise values for the dose rates of their Co-60 gamma sources. Recently, interest in the use of benzene-in-water dosimetry has been revived with the studies of Johnson and Martin.¹ This method is based on the production of phenol and other products when an aqueous solution of benzene is irradiated by gamma rays. Unlike the ferrous-sulfate dosimeter the benzene-in-water gamma dosimeter gives consistent results even when impure reagents and other ions are present in the solution. Furthermore, the latter is less corrosive and is stable for long times both before and after irradiation. Hence, these benzene-in-water dosimeters can be contained in plastic containers and sent to distant Co-60 teletherapy units by parcel post for irradiation and analyzed for phenol yield at a convenient laboratory to obtain the dose rate. It is for this purpose that this work was undertaken.

PROCEDURE

Reagent grade benzene was mixed with triple-distilled water until a saturated solution of benzene in water was obtained (0.021 M benzene). The stock solution was kept saturated by allowing a layer of benzene to remain over the solution in storage at room temperature. Fifteen ml portions of the aqueous layer were carefully transferred by a pipette in glass ampoules and sealed.

The samples were irradiated at the North General Hospital and St. Luke's Hospital Co-60 teletherapy units² using a

¹ Nucleonics (1) 20 (1962) 83.

² The Co-60 teletherapy units used were Shimadzu, 1990 curies (September, 1958) and Keleket-Barnes, 1500 curies (August, 1959) of North General Hospital and St. Luke's Hospital, respectively.

16 × 16 cm opening. The output of the sources were measured by a Victoreen rate meter recently standardized by the National Bureau of Standards of Washington, D.C., U.S.A.

The phenol yield was determined by using the difference in the absorptions of neutral and alkaline phenol solutions at 290 m μ .³ This method minimizes interferences due to those products of irradiation which have no appreciable difference in UV absorption spectra of neutral and alkaline solutions. The alkaline samples were prepared by adding 5 ml of 0.06 N NaOH to 5 ml of the irradiated solution while the neutral samples were prepared by diluting the irradiated solution with an equal volume of distilled water. Figs. 1, 2, and 3 show the absorption curves of neutral and alkaline solutions of phenol in benzene and water, unirradiated benzene in water, and irradiated benzene in water solutions, respectively, in the region 210 to 340 m μ .

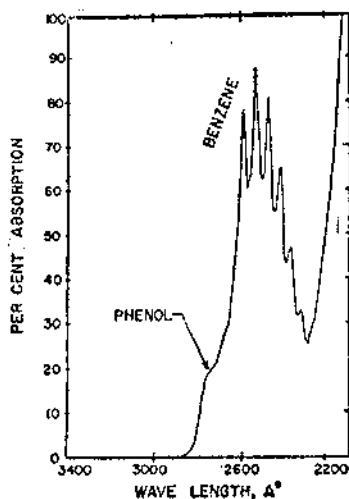


FIG. 1a. Absorption curve of neutral phenol and benzene-water solution.

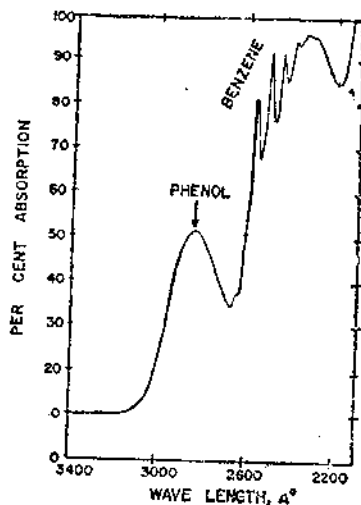


FIG. 1b. Absorption curve of alkaline phenol and benzene-water solution.

Ten minutes after the addition of NaOH the optical density of the alkaline sample, D_{as} , was measured at 290 m μ using distilled water as a reference. Similarly, the optical densities

³ Jour. Chem. Phys. 20 (1952) 1817.

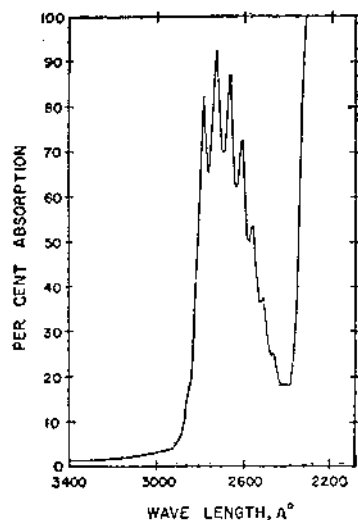


FIG. 2b. Absorption curve of unirradiated neutral benzene-water solution.

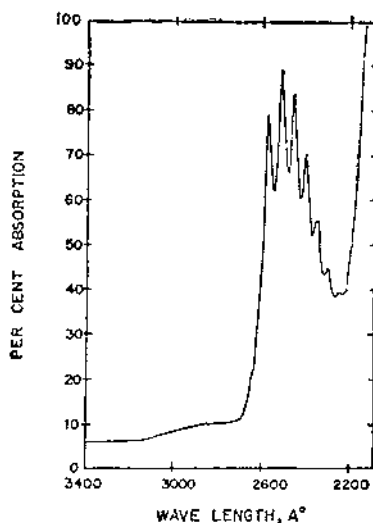


FIG. 2b. Absorption curve of unirradiated alkaline benzene-water solution.

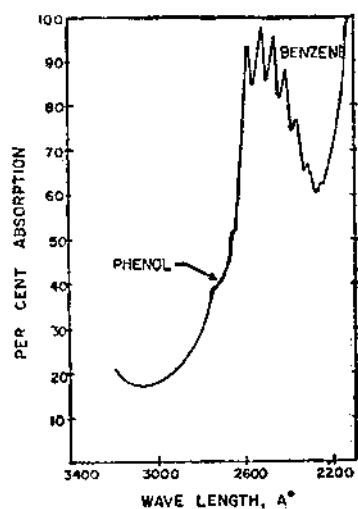


FIG. 3a. Absorption curve of gamma irradiated neutral benzene-water solution.

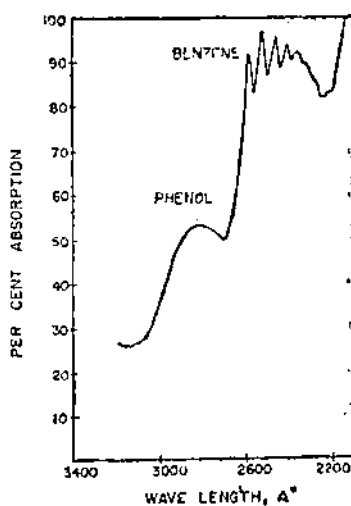


FIG. 3b. Absorption curve of gamma irradiated alkaline benzene-water solution.

of the neutral sample, D_{ns} , the alkaline blank solution, D_{ab} and the neutral blank solution, D_{nb} , were obtained using the same 1-cm cell; and the phenol concentration was calculated from

$$P = fk [(D_{ns} - D_{nb}) - (D_{ab} - D_{nb})]$$

Where P = phenol concentration in micromole/liter

f = dilution factor (= 2 in this report)

k = phenol calibration constant = $10^6/E_p$

p = path length of cell (= 1 cm in this report)

and E = molar extinction coefficient

= $2520 \pm 10(1)$ liters/mole cm of phenol

RESULTS AND DISCUSSIONS

The first objective of this investigation was to determine the linearity of phenol yield with respect to the amount of Co-60 gamma rays emanating from a teletherapy machine to which the benzene-water dosimeter is exposed. The results are shown in Fig. 4: which proves the linear function of phenol

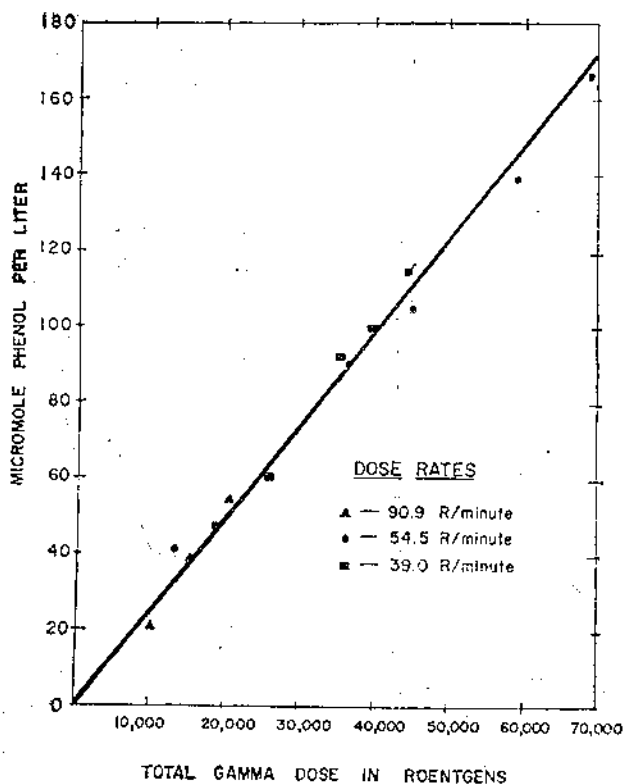


FIG. 4. Phenol yield versus total Co-60 gamma dose in benzene-water solutions.

yield up to 70,000 roentgens and at the various dose rates given; namely, 90.9, 54.5, and 39.0 roentgens per minute. The experimental values obtained are given below in Table 1.

TABLE 1.—*Phenol yields of benzene-water solutions irradiated with Cobalt-60 gamma rays.*

Hospital	Distance from source	Dose rate	Exposure time	Phenol yield
North General Hospital	cm 70.4	rad/min 39.0	hours	μ mole/liter
			8	47.57
			11	60.46
			15	87.46
			17	99.36
			19	111.43
North General Hospital	58.4	54.5	4	41.47
			8	60.53
			11	90.68
			14	104.97
			18	139.10
			21	166.08
St. Luke's Hospital	45.5	90.9	1.83	20.84
			2.75	38.30
			3.67	54.17

The second objective was to find any recovery effect of the benzene-water dosimeter; results have shown the phenol concentration to be independent of time.

An attempt to calculate the exact curie strength of the Co-60 sources based on the dosage results was made but no accurate values were obtained. This may be due to the scattering effects of the lead collimators on the benzene-water solution which were located close to the machine.

In conclusion, it has been found that Co-60 teletherapy machine gamma-radiation dosages can be determined within reasonable accuracy using benzene-in-water dosimeters.

ACKNOWLEDGMENT

The authors wish to express their gratitude to Mr. B. C. Bernardo and the Health Physics Department in making arrangements for the Co-60 irradiations; to the North General and St. Luke's Hospitals for the use of their Co-60 teletherapy machines; and to the University of the Philippines' Chemistry Department for the use of their hydrogen lamp and power supply.

USE OF ORDINARY TABLE SALT AGAINST BREEDING OF MOSQUITOES IN ARTIFICIAL CONTAINERS *

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SEVEN TEXT FIGURES

The earliest published study on the effects of salt concentrations and sea water on *Aedes ægypti* larvæ seems to be that of MacFie (1914), who reported:

0.5 per cent salt	little effect.
2.0 per cent salt	many died in 6 hours; all died in 12 hours.
2.3 per cent salt	larvæ rapidly killed.

In another study (1922), using sea water, he concluded:

In pure sea water (about 3.2 per cent salt)—larvæ killed in 2 to 4 hours.
In 50 per cent sea water (that is, about 1.6 per cent salt)—larvæ killed in 24 hours.

Wigglesworth (1933) was the next to study the effects of salt on the larvæ of *ægypti*. His results were:

0.9 per cent salt or less	larvæ not affected.
1.0 per cent salt	larvæ died in about one week.
1.3 per cent salt	larvæ died in about 72 hours.
1.4 per cent salt	larvæ died in about 48 hours.

Pentazis (1935), working in Greece, summarized his observations, thus:

0.5 to 1.0 salt per mille	optimum salinity.
5.0 salt per mille	development of larvæ prevented.

Bates (1939) used salt solution not as a larvicide but merely to measure the degree of tolerance of larvæ to various grades of salinity of the water. He claimed the tests were useful in determining the different subspecies of *Anopheles maculipennis* complex in Europe; they differed in salinity tolerance.

* Conducted at the Institute of Malariology, Tala, Caloocan City. Part of earlier data submitted for graduation at Araneta University included with due permission of the university authorities.

King and Del Rosario (1938), working in the salt ponds of Las Piñas, Rizal Province, Philippine Islands, discussed the salinity limit in which the salt-water-breeding *Anopheles (Cellia) litoralis* King, 1932, could survive. They found *litoralis* larvæ in the ponds having 8.8 per cent salt content, but above that concentration breeding ceased. Hence, this mosquito, which breeds by the millions all around Manila Bay and all around the coastal area in the Philippines, gradually disappears during the height of the dry season when evaporation increases water salinity, as well as during very rainy days when salinity becomes very low. This is easily observed in fish ponds and salt beds near Manila.

Some fresh-water breeding mosquitoes also breed more or less successfully in saline waters. This is true in the Philippines as in other parts of the world. Among the local mosquitoes that have evidently become primarily or exclusively salt-water breeders are *Anopheles (Myzorrhynchus) gateri* Baisas, 1936; *Anopheles (Myzorrhynchus) samarensis* Rozeboom, 1951; *Anopheles (Cellia) litoralis* King, 1932; and *Culex (Culex) salinus* Baisas, 1938.

The unpublished work of Calingo and Corcega (1938) showed that in the laboratory *Anopheles litoralis* could breed with equal success in fresh and salt water. Calingo worked in the laboratory at Tala; whereas Corcega conducted his observations in a private house at Malabon, Rizal, right at the edge of *litoralis*-breeding grounds. They carried parallel series of laboratory breeding. In one they used salt water taken from Malabon fish ponds; in another, fresh water from a running stream. Actually, however, *litoralis* larvæ are very seldom found in fresh-water pools and other bodies of water close to salt-water coasts. *Litoralis* adults are long-distance fliers. They are frequently caught during the dry season in mosquito traps at Tala and elsewhere including localities in Mindanao some 20 kilometers or more away (in a straight line) from the nearest salt-water-breeding places. Repeated and thorough searches for breeding of *litoralis* in Tala were all negative.

EXPERIMENTAL PROCEDURES

The specimens of *Aedes ægypti* and *Aedes albopictus* used in the tests were from (a) their natural-breeding waters in the field, (b) colonies which had been maintained for several generations in the insectaries of the Institute of Malariology,

and (c) caught wild, gravid females. The gravid females were isolated individually in separate small lantern chimneys and allowed to lay eggs. The eggs hatched equally well when placed directly in breeding trays without maturation or when given 3-day maturation period before they were put in trays. Parallel tests of full-grown larvæ from the three foregoing sources were conducted. The results indicated hardly any difference among them.

Ten larvæ were found most convenient to use in each kind of glass jar used in the tests.

Preparatory to the tests, the glasswares (40 or more glass jars, graduated cylinders, graduated pipettes, glass rods, etc.) were thoroughly cleaned, oven-dried and then kept in a clean, covered cardboard box. Ordinary medicine droppers, etc., were also readied.

In the tests for either *ægypti* or *albopictus*, only nine jars were used in each test: one jar for control, four jars for tests using pure salt, and four jars for unpurified Las Piñas salt. These were in concentrations of 3, 5, 7, and 10 per cent.

Hourly observations were carried during office hours. Then final checking was done the next day after 24 hours' exposure.

Table 1 and the corresponding graph (Fig. 1) show that all third- and fourth-instar larvæ of *ægypti* were killed within 6 hours at 5 per cent, within 3 hours at 7 per cent, and in the first hour at 10 per cent.

Mortality was noted in the very first hour of exposure to the following salt concentration: 4 per cent mortality at 3 per cent concentration; 28, at 5 per cent; 75, at 7 per cent; and 99.8, at 10 per cent.

Survivals by pupation were present in all these concentrations; but the pupæ from 7 per cent and 10 per cent salt concentrations did not emerge into adults. (They were not removed from their respective salt concentrations until they either died or emerged into adults.) Hastening of pupation is said to be a natural reaction of insects to adverse conditions.

Susceptibility tests in salt concentrations made for the larvæ of *albopictus* followed rigidly the same procedure and hourly observations as those made for *ægypti* larvæ. The results of these tests are shown in Table 2 and the corresponding graph (Fig. 2).

The results for *albopictus* differed little from those of *ægypti*. More pupation at 3 per cent concentration occurred in *albopictus*

TABLE 1.—Results obtained for *A. ægypti* at the Institute of Malariology

Salt concentration	Number of larvæ tested	1-hour exposure			2-hour exposure			3-hour exposure		
		Alive	Total dead		Alive	Total dead		Alive	Total dead	
Per cent			Number	Per cent		Number	Per cent		Number	Per cent
3	420	465	15	4	320	80	19	161	259	61.6
5	420	362	118	28	* 143	277	66	** 26	394	94.0
7	420	107	313	75	** 9	411	98	** 2	418	99.5
10	420	* 1	419	99.8						

TABLE 2.—Results obtained for *A. albopictus* at the Institute of Malariology

Salt concentration	Number of larvæ tested	1-hour exposure			2-hour exposure			3-hour exposure		
		Alive	Total dead		Alive	Total dead		Alive	Total dead	
Per cent			Number	Per cent		Number	Per cent		Number	Per cent
3	400	398	2	0.5	316	84	21	* 167	233	58.0
5	400	294	106	27.0	145	255	64	24	376	99.7
7	400	92	308	77.0	15	385	96	1	399	97.7
10	400	10	390	97.5	-----	400	100			

NOTE: Each asterisk * represents one pupation. This is added to subsequent pupations and carried to the end of the 24-hour observations.

NOTE: All control larvæ were alive at the end of 24-hour observations.

than in *ægypti*; but this might have been due to the actual ages of the specimens tested or to the fact that some larvæ developed faster than others. One larva of *albopictus*, like one larva of *ægypti*, lived through 4 hours' exposure in 5 per cent concentration. At 7 per cent concentration no *ægypti* larva lived beyond 3 hours' exposure (except those that had pupated), while one *albopictus* larva survived 3 hours' exposure and succumbed only in the 4th hour. No pupation occurred in *albopictus* at 10 per cent concentration, but 10 larvæ survived through the first hour of exposure and died only in the second hour. On the other hand, one *ægypti* pupated; all others died in the first hour of exposure in 10 per cent salt concentration.

The axil breeders.—Of more than 20 species of mosquitoes that breed in axils of various plants, only *Aedes (Finlaya) pæcilus* (Theobald) 1903, as far as known at present, is of public health concern by virtue of its being the most numerous among axil breeders. It bites man readily and has consequently, become the main transmitter of filariasis, specially in the Bicol Provinces. It breeds in axils of several plants; but it thrives best in axils of abaca (*Musa textilis*) and bananas, specially the "saba" (*Musa sapientum compressa*).

The species identified after the tests are shown in Table 3.

and those in Araneta University combined. (For graph, see Fig. 1.)

4-hour exposure			5-hour exposure			6-hour exposure			Next day		
Alive	Total dead		Alive	Total dead		Alive	Total dead		Alive	Total dead	
	Number	Per cent		Number	Per cent		Number	Per cent		Number	Per cent
**82	338	80.0	**46	374	89.0	*3	417	99			
**3	417	99.9	**2	418	99.9						

and those in Araneta University combined. (For graph, see Fig. 2.)

4-hour exposure			5-hour exposure			6-hour exposure			Next day		
Alive	Total dead		Alive	Total dead		Alive	Total dead		Alive	Total dead	
	Number	Per cent		Number	Per cent		Number	Per cent		Number	Per cent
***			***			***			***		
100	300	75.0	*32	368	92	***10	390	98	***7	393	98
1	399	99.9	-----	400	100						
-----	400	100.0									

Tables 4 and 4a and the corresponding graphs (Fig. 3) show that the first- and second-instar larvæ survived longer exposures than the corresponding third- and fourth-instar larvæ. This was generally true in all species tested.

The larvæ of *sorsogonensis* sp. nov. were comparatively more resistant to salt concentrations than those of other axil-breeding species. This new species prefers to breed in axils of "ban-koang" (*Pandanus* sp.).

For some unknown reasons, salt concentrations with tap water as diluent kill the axil-breeding larvæ more slowly than the same concentrations with axil water as diluent.

TABLE 3.—Identification and classification of mosquito instars.

Species	Control instars					Treated instars				
	1st	2nd	3rd	4th	Total	1st	2nd	3rd	4th	Total
1. <i>Aedes (Finlaya) pacificus</i> (Theobald), 1903	13	38	62	91	204	23	36	52	68	179
2. <i>Aedes (Finlaya) ananoe</i> (Knight and Lafoon), 1946	13	17	30	85	145	18	36	26	72	152
3. <i>Aedes (Stegomyia) meronephada</i> (Dyar and Shannon), 1925	1	3	3	7	14	5	6	20	8	39
4. <i>Aedes (Finlaya) flavipennis</i> (Giles), 1904	1	2	-----	2	5	1	1	2	1	5
5. <i>Malaya genurostris</i> Leicester, 1908	3	3	3	-----	9	4	15	3	-----	22
6. <i>Aedes (Finlaya) sorsogonensis</i> sp. nov.	10	39	50	45	144	10	78	43	34	165
7. <i>Topomyia barbus</i> Bañes, 1946	4	15	20	25	64	2	14	8	19	43
Total	45	107	168	255	585	61	184	143	197	605

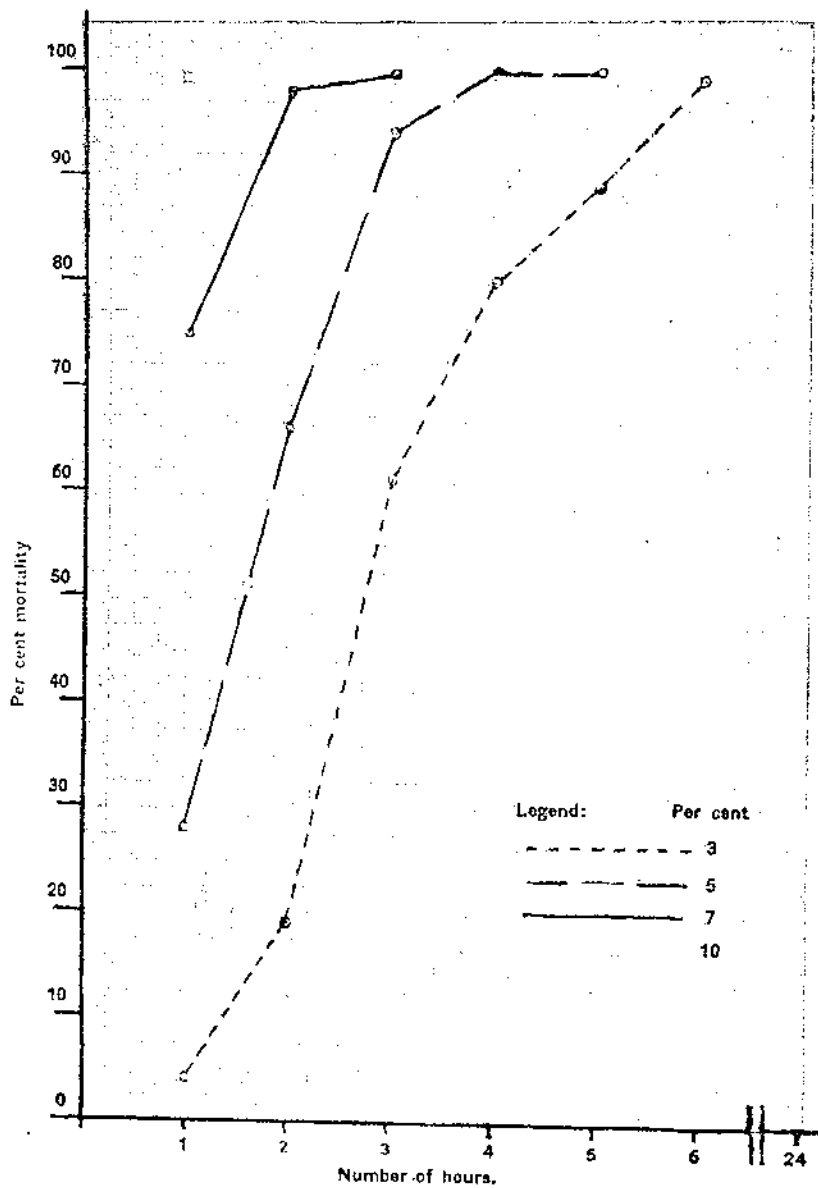


FIG. 1. Results obtained for *aegypti* at the Institute of Malariology and those in Araneta University combined.

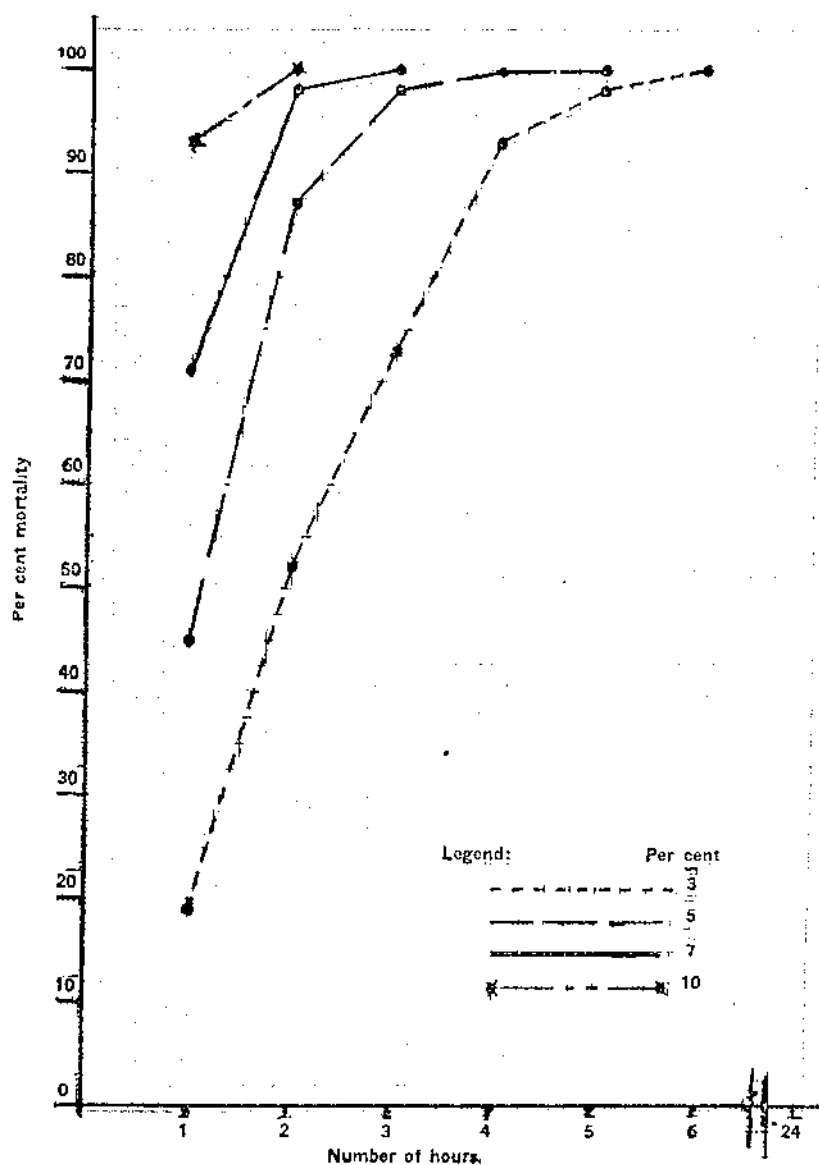


FIG. 2. Results obtained for *albopitcus* at the Institute of Malariology and those in Araneta University combined.

TABLE 4.—Results of exposing larvæ of axil-breeding mosquitoes to 5 per

Salt concentration	Number of larvæ tested	1-hour exposure			2-hour exposure			3-hour exposure		
		Alive	Total dead		Alive	Total dead		Alive	Total dead	
			Number	Per cent		Number	Per cent		Number	Per cent
Form:	BANANAS									
P + a. w.	50	45	5	10	31	19	38	16	34	68
R + a. w.	40	40			40			28	12	30
R + t. w.	10	10			10			10		
Total...	100	95	5	5	81	19	19	54	46	46
P + a. w.	15	15			15			15		
R + a. w.	15	15			15			15		
P + t. w.	15	8	7	47	6	9	60	4	11	73
R + t. w.	15	15			13	2	14	10	5	33
Total...	60	53	7	12	49	11	18	44	16	27
P + a. w.	15	15			15			15		
R + a. w.	15	15			15			15		
P + t. w.	15	15			12	3	20	6	9	60
R + t. w.	15	15			15			13	2	14
Total...	60	60			57	3	5	49	11	18
P + a. w.	15	15			15			15		
R + a. w.	15	15			15			15		
P + t. w.	15	15			14	1	7	11	4	27
R + t. w.	15	12	3	20	11	4	27	9	6	40
Total...	60	57	3	5	55	5	8	50	10	17

TABLE 4a.—Results of exposing larvæ of axil-breeding mosquitoes to 10

Salt concentration	Number of larvæ tested	1-hour exposure			2-hour exposure			3-hour exposure		
		Alive	Total dead		Alive	Total dead		Alive	Total dead	
			Number	Per cent		Number	Per cent		Number	Per cent
From:	BANANAS									
P + a. w.	25	10	15	60	5	20	80		25	100
R + a. w.	10	10			5	5	50	4	6	60
P + t. w.	25		25	100		25	100		25	100
R + t. w.	25		25	100		25	100		25	100
Total...	85	20	65	76	10	75	88	4	81	95
P + a. w.	15		15	100		15	100		15	100
P + t. w.	15		15	100		15	100		15	100
R + a. w.	15	3	12	80	3	12	80		15	100
R + t. w.	15		15	100		15	100		15	100
Total...	60	3	57	95	3	57	95		60	100
P + a. w.	15	5	10	67	4	11	73		15	100
P + a. w.	15	3	12	80	1	14	93		15	100
R + a. w.	15	7	8	53	3	12	80		15	100
R + t. w.	15	3	12	80	1	14	93		15	100
Total...	60	18	42	70	9	51	85		60	100
P + a. w.	15	15			5	10	67		15	100
P + t. w.	15		15	100		15	100		15	100
R + a. w.	15	8	7	47	4	11	73		15	100
R + t. w.	15		15	100		15	100		15	100
Total...	60	23	37	62	9	51	85		60	100

ABBREVIATIONS use: P, pure salt; R, raw salt; a.w., axil water; t. w., tap water.
 NOTE: All control larvæ were alive at the end of 24-hour observations.
 * The tests were performed at the Institute of Malakology.

salt concentration.* (For graphs, see Fig. 3.)

4-hour exposure			5-hour exposure			6-hour exposure			Next day		
Alive	Total dead		Alive	Total dead		Alive	Total dead		Alive	Total dead	
	Number	Per cent		Number	Per cent		Number	Per cent		Number	Per cent
10	40	80	10	40	80	7	43	86		50	100
17	23	68	13	27	68	10	30	75	6	35	88
10			4	6	60	2	8	80		10	100
37	63	63	27	73	73	19	81	81	5	95	95
16			15			15			5	10	67
15			13	2	14	10	5	33	5	10	67
	16	100		15	100		15	100		15	100
5	10	67	2	13	87		15	100		15	100
35	25	42	30	30	50	25	35	71	10	50	83
15			12	3	20	10	5	33		15	100
16			15			15			13	2	14
4	11	73	1	14	83		15	100		15	100
4	4	27	5	10	67	2	13	87		15	100
45	15	25	33	27	45	27	33	55	13	47	78
14	1	7	8	7	47	7	8	54		15	100
15			15			14	1	7	9	6	40
	15	100		15	100		15	100		15	100
5	10	67		15	100		15	100		15	100
34	26	47	23	37	62	21	39	65	9	61	85

per cent salt concentration.* (For graph, see Fig. 3.)

[illegible]

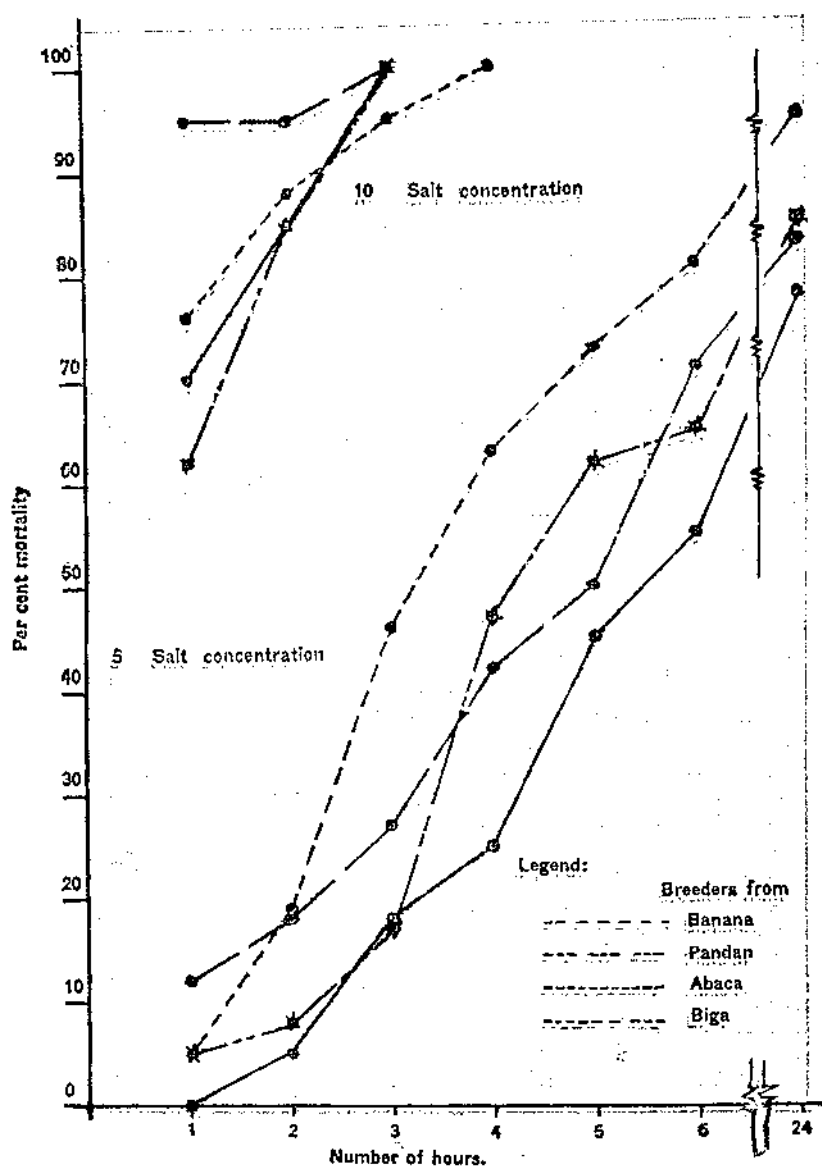


FIG. 3. (Superimposed). Results of exposing larvæ of axil-breeding mosquitoes to 5 and 10 per cent salt concentrations.

Breeders in fresh-water collections on the ground.—Collections of fresh water on the ground may be classified according to the species of mosquitoes that prefer to breed in them. The classification, however, cannot be absolute since overlapping breeding preferences occur, and some species have wider adaptations to various types of breeding waters than others. Perpetuation of any mosquito species in nature largely depends upon its success to breed in different types of waters. *Culex pipiens quinquefasciatus*, better known in the Philippines as *Culex fatigans*, thrives best in very highly polluted waters where no other mosquito species can breed; though lightly, in cleaner waters. On the other hand, *Anopheles flavirostris*, the primary vector of malaria in the Philippines, breeds best in small, flowing streams, although it may be found in other places. However, it cannot breed in foul waters, which suit *fatigans* best.

The larvæ used in the tests came from three sources: (a) Streams; namely, Alat River, Bugos and Malamig Creeks, which are all in Tala and the immediate vicinity. These are all with permanently running water. (b) Rice paddies, at the time rice plants were only about a foot high. The mosquito fauna in rice paddies varies somewhat according to whether the paddies are planted with rice or not, whether the plants are tall or young, etc. When already very thick, the rice plants prevent or reduce mosquito breeding. When not planted but watered, other species of mosquitoes breed in them. At the time of the experiment, the rice paddies in the Araneta University compound were highly polluted, as indicated by the fairly heavy breeding of *quinquefasciatus* in them; whereas those in Tala were cleaner and had species that prefer to breed in cleaner waters. (c) Ponds: Portions of the pond in the Araneta University compound directly affected by the slight flow of water from a canal had cleaner water than the stagnated highly polluted parts. In consequence, species preferring cleaner waters were found in the cleaner parts: whereas *quinquefasciatus* was quite numerous in the polluted portions. The specimens from ponds used in the experiments were mostly *quinquefasciatus*.

(a) *Stream breeders.*—Two thousand eight hundred larvæ, representing 17 stream-breeding anopheline and culicine mosquitoes were tested. For control, 450 larvæ of the same

species were used. As in other tests, only the full-grown larvæ were selected. Their distribution was as follows:

	Control	Tested
1. <i>Anopheles</i> (<i>Anopheles</i>) <i>barbirostris</i> Van der Wulp, 1884	0	5
2. <i>Anopheles</i> (<i>Anopheles</i>) <i>manalangi</i> Mendoza, 1946	3	59
3. <i>Anopheles</i> (<i>Anopheles</i>) <i>peditæniatus</i> (Leicester), 1908	4	75
4. <i>Anopheles</i> (<i>Cellia</i>) <i>annularis</i> Van der Wulp, 1884	2	142
5. <i>Anopheles</i> (<i>Cellia</i>) <i>filipina</i> Manalang, 1930	31	125
6. <i>Anopheles</i> (<i>Cellia</i>) <i>maculatus</i> Theobald, 1901	0	2
7. <i>Anopheles</i> (<i>Cellia</i>) <i>minimus flavirostris</i> (Ludlow), 1914	170	1,259
8. <i>Anopheles</i> (<i>Cellia</i>) <i>philippinensis</i> Ludlow, 1902	3	6
9. <i>Anopheles</i> (<i>Cellia</i>) <i>vagus limosus</i> King, 1932	58	411
10. <i>Culex</i> (<i>Culex</i>) <i>annulus</i> Theobald, 1901	71	114
11. <i>Culex</i> (<i>Culex</i>) <i>bitæniorhynchus</i> Giles 1901	15	60
12. <i>Culex</i> (<i>Culex</i>) <i>fuscocephalus</i> Theobald, 1907	35	190
13. <i>Culex</i> (<i>Culex</i>) <i>incognitus</i> Baisas, 1938	14	98
14. <i>Culex</i> (<i>Culex</i>) <i>tritæniorhynchus summorosus</i> Dyar, 1920	34	182
15. <i>Culex</i> (<i>Culex</i>) <i>fuscus</i> Wiedemann, 1820	4	20
16. <i>Ficalbia</i> (<i>Mimomyia</i>) <i>chamberlaini</i> Ludlow, 1904	0	2
17. <i>Uranotænia atra</i> Theobald, 1905	6	50
Total	450	2,800

The results of the tests are shown in Table 5 and its corresponding graph (Fig. 4).

Compared with those that breed in artificial containers and axils of plants, the stream breeders were evidently a little more susceptible to salt concentrations. None of the stream breeders survived after six hours' exposure to salt at 3 per cent concentration. In 5 per cent, only one was still alive after four hours' exposure, but this also died during the fifth hour. Only 15 or 1.875 per cent survived two hours of exposure in 7 per cent salt, but they all succumbed during the third hour. Twenty-eight larvæ, or 7 per cent, survived an hour's exposure in 10 per cent solution, but were killed in the second hour. Those that survived longest in each concentration were the large species; namely, *Anopheles barbirostris*, *Anopheles manalangi*, *Anopheles peditæniatus*, *Culex bitæniorhynchus*, and *Culex fuscus*. The largest of these, *fuscus*, generally survived longest. Ten of them were tested together in 10 per cent salt concentration. They all lived through the first hour, but died in the second.

During these tests 7 pupations occurred among those used as control. All became normal adults and were subsequently

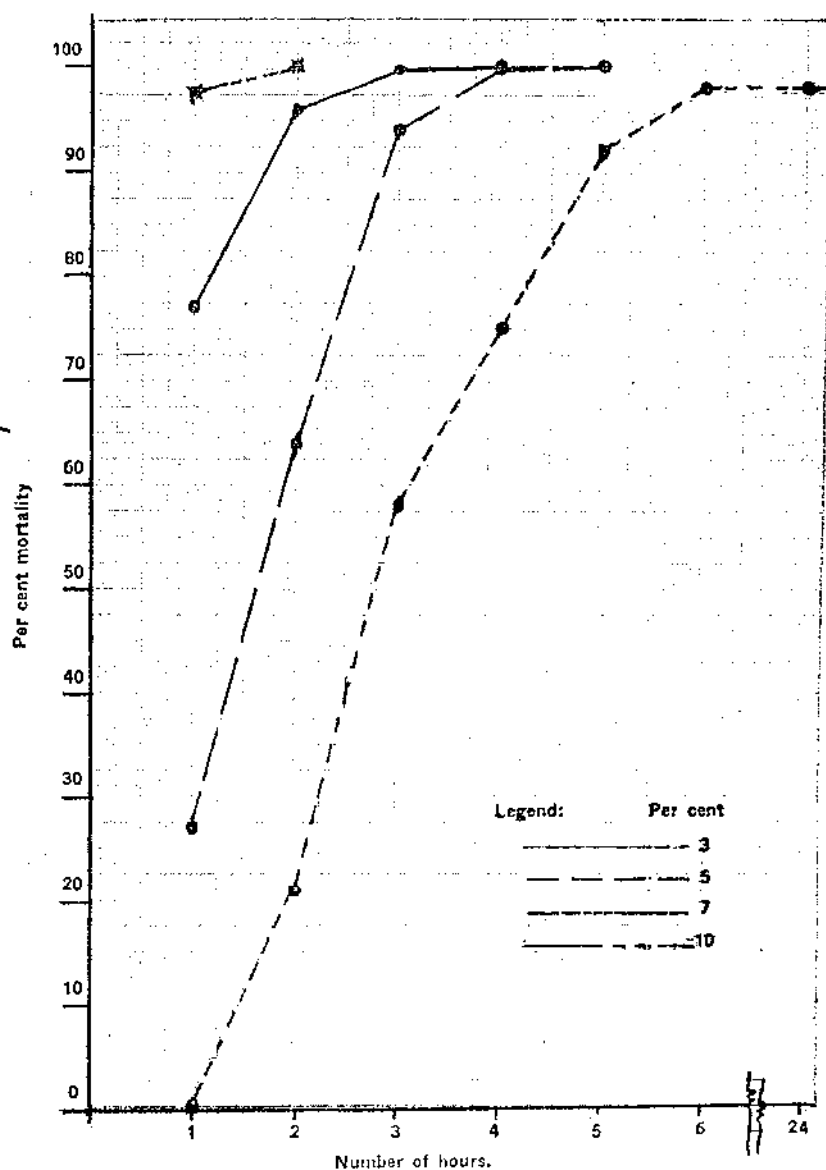


FIG. 4. Results of exposing larvæ of stream-breeding mosquitoes to 3, 5, 7, and 10 per cent salt concentrations.

TABLE 5.—Results of exposing larvæ of stream-breeding mosquitoes to 2,

Salt concentration	Number of larvae tested	1-hour exposure				2-hour exposure			3-hour exposure		
		Alive	Total dead		Alive	Total dead		Alive	Total dead		
			Number	Per cent		Number	Per cent		Number	Per cent	
3 per cent											
P + o. w.	200	161	39	20	89	111	56	47	153	77	
R + o. w.	200	171	29	15	93	107	54	70	130	65	
P + t. w.	200	152	48	24	99	101	51	59	141	71	
R + t. w.	200	165	35	18	101	99	60	40	160	80	
Total...	800	649	151	19	382	418	52	216	584	73	
5 per cent											
P + o. w.	200	93	107	54	26	174	87	---	200	100	
R + o. w.	200	104	96	48	26	174	87	4	196	98	
P + t. w.	200	122	78	39	31	169	85	3	197	99	
R + t. w.	200	120	80	40	19	181	91	7	193	97	
Total...	800	439	361	45	102	698	87	14	786	98	
7 per cent											
P + o. w.	200	40	160	80	2	198	99	---	200	100	
R + o. w.	200	62	138	69	5	195	98	---	200	100	
P + t. w.	200	60	140	70	2	198	99	---	200	100	
R + t. w.	200	68	132	66	6	194	97	---	200	100	
Total...	800	230	570	71	15	785	98	---	800	100	
10 per cent											
P + o. w.	200	---	200	100	---	200	100	---	---	---	
R + o. w.	200	28	172	86	---	200	100	---	---	---	
Total...	400	28	372	93	---	400	100	---	---	---	

ABBREVIATIONS USED: P, pure salt; R, raw salt; o.w., original breeding water; t.w., tap water.

NOTE: All control larvæ were alive at the end of 24-hour observations.

* The tests were performed at the Institute of Malariology.

identified as follows: 2 ♂♂ and 2 ♀♀ *flaviviridis*, 2 ♂♂ *limosus*, and 1 ♀ *summorosus*. Five pupations occurred among those that were tested, all of which emerged into adults: 1 ♂ *manalangi*, which pupated in 10 per cent salt; 2 ♀♀ *fuscocephalus*; and 1 ♂ and 1 ♀ *summorosus*, which pupated in lower concentrations.

Although the tests of stream-breeding mosquito larvæ were carried without any quixotic intention of applying salt concentrations in actual mosquito-abatement programs, it is interesting to note that *flaviviridis* (the principal vector of malaria in the Philippines) was found very susceptible to salt solutions.

(b) *Rice-field breeders*.—Two thousand four hundred and

TABLE 6.—Number and types of mosquitoes exposed to salt concentrations.

Species	Control	Salt concentrations				
		3 per cent	5 per cent	7 per cent	10 per cent	Total
1. <i>annulus</i>	35	51	49	58	49	210
2. <i>bitaeniorhynchus</i>	22	20	18	26	21	85
3. <i>fuscocephalus</i>	145	230	234	226	210	950
4. <i>golidus</i>	45	65	19	32	53	189
5. <i>summorosus</i>	150	239	243	235	219	586
Total	400	708	563	597	250	2,420

5, 7, and 10 per cent salt concentrations.* (For graph, see Fig. 4.)

4-hour exposure			5-hour exposure			6-hour exposure			Next day		
Alive	Total dead		Alive	Total dead		Alive	Total dead		Alive	Total dead	
	Number	Per cent		Number	Per cent		Number	Per cent		Number	Per cent
19	181	91	11	189	95	-----	200	100			
18	182	91	-----	200	100	-----	200	100			
8	192	96	2	198	99	-----	200	100			
14	186	93	6	194	97	-----	200	100			
59	741	93	19	781	98	-----	800	100			
-----	200	100	-----	200	100						
-----	200	100	-----	200	100						
1	199	99.5	-----	200	100						
-----	200	100	-----	200	100						
1	799	99.8	-----	800	100						

twenty larvæ from the rice-field in Tala were tested; 400 were used for control. These are shown in Table 6.

The results of the tests are shown in Table 5 and its corresponding graphs (Figs. 5 and 5a).

One thousand four hundred and eighty larvæ from the rice paddies in the compound of the Araneta University were also tested; 200 were used for control. After the tests, they were identified as:

	Control	Tested
1. <i>annulus</i>	149	284
2. <i>quinquefasciatus</i>	38	1,043
3. <i>limosus</i>	13	153
Total	200	1,480

The only difference noted was in the 10 per cent salt concentration: all larvæ (mostly *quinquefasciatus*) from the Araneta University rice paddies died in the first hour of exposure, whereas 9 of those from Tala rice paddies survived the first and second hours and died only in the third hour.

(c) *Pond breeders*.—At the time the experiments were undertaken (January to March, 1961), the pond in the compound of the Araneta University had most of its parts highly polluted, while portions along the edges were clearer. *Culex pipiens quinquefasciatus* had heavy breeding in the highly polluted parts; while other species, besides a few *quinquefasciatus*, were

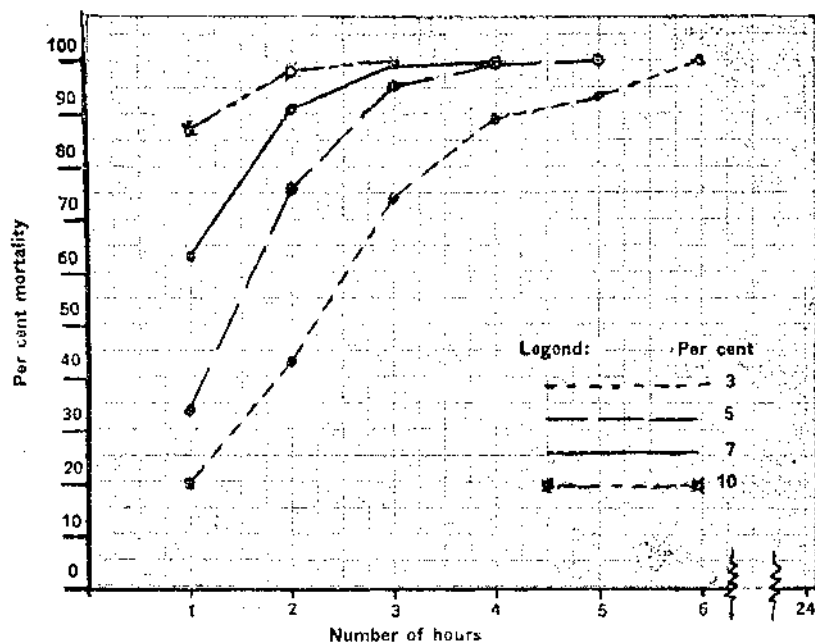


FIG. 5. Results of exposing larvæ of rice-field breeding mosquitoes to 3, 5, 7, and 10 per cent salt concentrations.

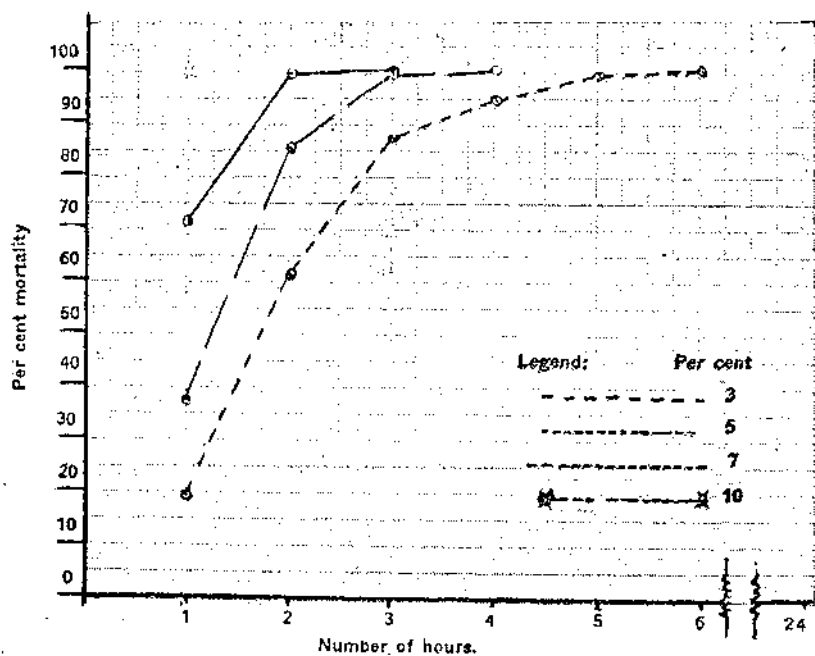


FIG. 5a. Results of exposing larvæ of pond-breeding mosquitoes to 3, 5, 7, and 10 per cent salt concentrations.

present along the cleaner edges. It may be remarked here that *quinquefasciatus* in the most important transmitter of filariasis in many parts of the Oriental Region; but in the Philippines, this mosquito plays a very minor role, if at all, in the transmission of local filariasis.

Six hundred and forty larvæ from the Araneta pond were used in the tests; 110, for control. Identification after the tests showed:

1. <i>annulus</i>	7	5
2. <i>quinquefasciatus</i>	42	354
3. <i>summosus</i>	38	271
4. <i>limosus</i>	23	10
Total	110	640

The results were very close to those of other tests. See Table 8 and corresponding graph (Fig. 6).

DISCUSSION

The experiments were undertaken primarily to determine whether or not salt concentrations may be effectively and economically used in the control of the disease-carrying mosquitoes that breed in artificial containers. These mosquitoes are *Aedes* (*Stegomyia*) *ægypti* and *Aedes* (*Stegomyia*) *albopictus*. For comparative purposes, at least in the laboratory, various other species that breed in plant containers and in different types of ground waters were also tested. However, the impracticability of using salt against the breeding of mosquitoes in large bodies of water, like ponds, rivers and streams, and even in the enormous numbers of plant containers such as the axils of abaca and bananas, is obvious.

The foregoing tables, 1, 2, 4, 5, 7 and 8, and their corresponding graphs show the results of the tests according to species (in the case of *Aedes ægypti*, Table 1: and *Aedes albopictus*, Table 2), and according to the type of breeding waters (in the case of axil breeders, Table 4: stream breeders, Table 5; rice-field breeders, Table 7: and pond-breeders, Table 8).

Table 9 is a summary of the preceeding tables except Table 4. The tests for those that breed in axils (Table 4) were for all larval instars, and are, thereby, not strictly comparable with the other tests in which only the third and fourth-instar larvæ were used. Generally, the first- and second-instar larvæ

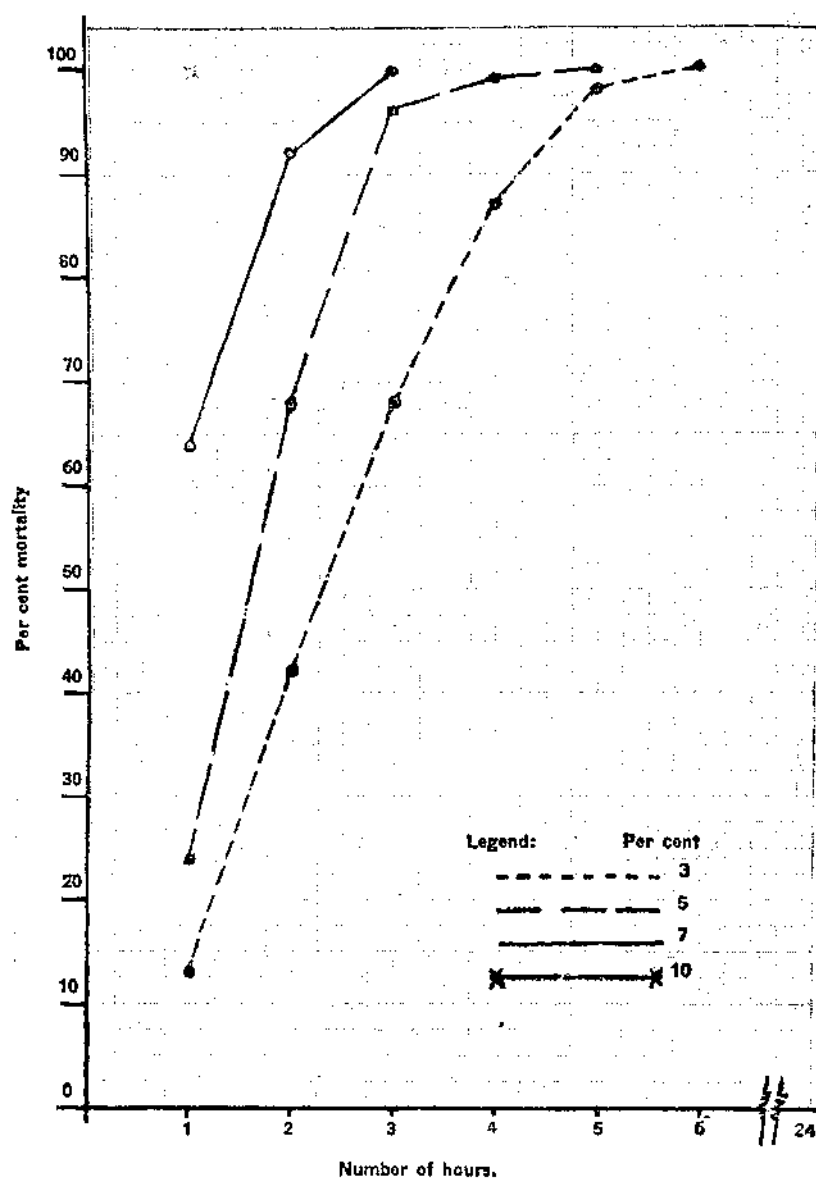


FIG. 6. Results of exposing larvæ of pond-breeding mosquitoes to 3, 5, 7, and 10 per cent salt concentrations.

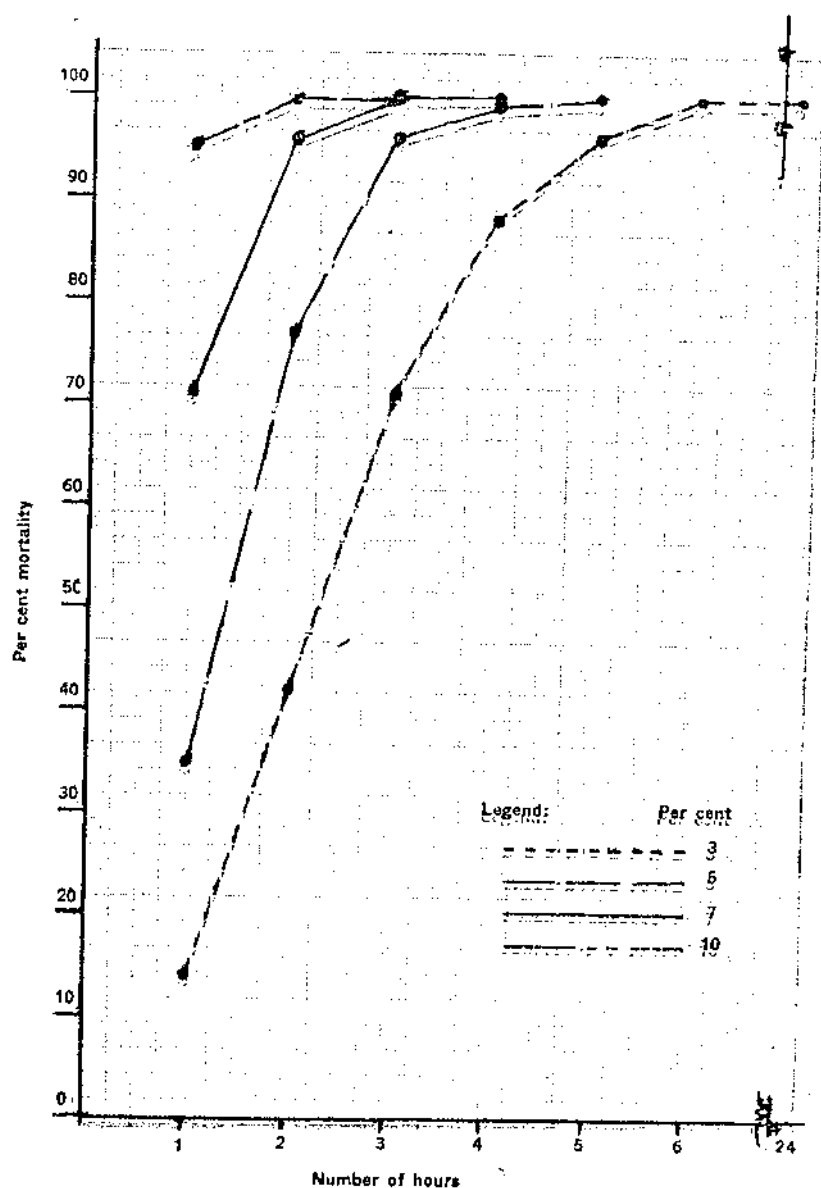


FIG. 7. Summary of all tests excluding those for axil breeders.

TABLE 7.—Results of exposing larvae of rice-field-breeding mosquitoes to

Salt concentration	Number of larvae tested	1-hour exposure			2-hour exposure			3-hour exposure		
		Alive	Total dead		Alive	Total dead		Alive	Total dead	
			Number	Per cent		Number	Per cent		Number	Per cent
3 per cent										
P + o. w.	170	136	34	20	96	74	44	47	123	72
R + o. w.	170	139	31	18	91	79	46	29	141	83
P + t. w.	170	156	14	8	113	57	34	50	120	71
R + t. w.	170	121	49	29	85	85	50	54	116	68
Total...	680	552	128	20	385	295	43	180	500	74
5 per cent										
P + o. w.	170	105	65	38	29	141	84	8	162	95
R + o. w.	170	127	43	25	49	121	71	17	153	90
P + t. w.	170	113	57	34	36	134	79	—	170	100
R + t. w.	170	106	64	38	53	117	69	9	161	95
Total...	680	451	229	34	167	513	76	34	646	95
7 per cent										
P + o. w.	170	41	129	76	5	165	97	2	168	99
R + o. w.	170	86	84	49	39	131	77	—	170	100
P + t. w.	170	35	135	79	1	169	99	—	170	100
R + t. w.	170	87	83	49	18	152	89	—	170	100
Total...	680	249	431	63	63	617	91	2	678	99.6
10 per cent										
P + o. w.	220	13	207	94	4	216	98	—	220	100
R + o. w.	160	36	124	78	5	155	97	—	160	100
Total...	380	49	331	87	9	371	98	—	380	100

* The tests were performed at the Araneta University.

TABLE 7a.—Results of exposing larvae of rice-field-breeding mosquitoes to

Salt concentration	Number of larvae tested	1-hour exposure			2-hour exposure			3-hour exposure		
		Alive	Total dead		Alive	Total dead		Alive	Total dead	
			Number	Per cent		Number	Per cent		Number	Per cent
3 per cent										
P + o. w.	110	79	31	28	45	65	59	9	101	92
R + o. w.	110	87	23	20	37	73	66	15	95	86
P + t. w.	100	92	8	8	51	49	49	24	76	76
R + t. w.	160	81	19	19	32	68	68	7	93	93
Total...	420	339	81	19	165	255	61	55	365	87
5 per cent										
P + o. w.	110	55	55	50	9	101	92	1	109	99
R + o. w.	110	71	39	35	23	87	79	2	108	98
P + t. w.	100	85	15	15	25	75	75	2	98	98
R + t. w.	100	63	47	47	7	93	93	—	100	100
Total...	420	264	156	37	64	356	85	5	415	99
7 per cent										
P + o. w.	110	24	86	78	2	108	98	—	110	100
R + o. w.	110	25	85	77	1	109	99	—	110	100
P + t. w.	100	28	72	72	—	100	100	—	100	100
R + t. w.	100	18	82	82	—	100	100	—	100	100
Total...	420	95	325	71	3	417	99	—	420	100
10 per cent										
P + o. w.	110	—	110	100	—	—	—	—	—	—
R + o. w.	110	—	110	100	—	—	—	—	—	—
Total...	220	—	220	100	—	—	—	—	—	—

Abbreviations used: P, pure salt; R, raw salt; o. w., axil water; t. w., tap water.

NOTE: All control larvae were alive at the end of 24-hour observations.

* The tests were performed at the Institute of Malariology.

3, 5, 7, and 10 per cent salt concentrations.* (For graph, see Fig. 5.)

4-hour exposure			5-hour exposure			6-hour exposure		Next day	
Alive	Total dead		Alive	Total dead		Alive	Total dead	Alive	Total dead
	Number	Per cent		Number	Per cent		Number	Number	Per cent
27	143	84	2	168	99	-----	170	100	
10	160	94	2	168	99	-----	170	100	
15	155	91	-----	170	100	-----	170	100	
18	152	89	10	160	94	-----	170	100	
70	610	89	14	666	93	-----	680	100	
-----	170	100	-----	170	100				
3	167	98	-----	170	100				
-----	170	100	-----	170	100				
2	168	99	-----	170	100				
5	675	99	-----	680	100				
-----	170	100							
-----	170	100							
-----	170	100							
-----	170	100							
-----	680	100							

3, 5, 7, and 10 per cent salt concentrations.* (For graph see Fig. 5a.)

4-hour exposure			5-hour exposure			6-hour exposure		Next day	
Alive	Total dead		Alive	Total dead		Alive	Total dead	Alive	Total dead
	Number	Per cent		Number	Per cent		Number	Number	Per cent
6	104	95	-----	110	100	-----	110	100	
8	102	93	2	108	98	-----	110	100	
12	88	88	3	97	97	-----	100	100	
1	99	99	-----	100	100	-----	100	100	
27	393	94	5	415	99	-----	420	100	
-----	110	100							
-----	110	100							
-----	100	100							
-----	100	100							
-----	420	100							

of all species are more resistant to salt concentrations than their respective third- and fourth-instars. Likewise, those that breed in plant axils are evidently less susceptible to salt than those that breed in other types of water. The contrast between axil breeders and those that breed elsewhere (comparing Tables 4 and 4a with Tables 1, 2, 4, 7, and 8) may be appreciated by the survival of 37 young larvæ (13.2 per cent) in 5 per cent salt after 24 hours' exposure and the survival of only 2 *Aedes ægypti* and 3 *Aedes albopictus* out of 2,900 larvæ of different species after only 6 hours' exposure in other tests. Survival beyond 6 hours was by pupation.

In 3 per cent salt, mortality among the larvæ rapidly increased from the first to the fifth hour of exposure. The very few that survived 5 hours' exposure died in the sixth. However, those that pupated during exposure survived and successfully reached the adult stage in this medium. This means that 3 per cent salt apparently did not hamper the development of the adult in the pupal stage.

Out of 2,900 larvæ tested in 5 per cent salt, only 12 larvæ and 2 that pupated survived 4 hours of exposure. The

TABLE 8.—Results of exposing larvæ of pond-breeding mosquitoes to 3,

Salt concentration	Number of larvæ tested	1-hour exposure		2-hour exposure		3-hour exposure	
		Alive	Total dead	Alive	Total dead	Alive	Total dead
			Number Per cent		Number Per cent		Number Per cent
3 per cent							
P + o. w.	40	30	10 25	21	19 48	10	30 75
R + o. w.	40	40	—	37	3 8	19	21 53
P + t. w.	50	45	5 10	24	26 52	11	39 78
R + t. w.	50	42	8 16	23	27 54	17	33 66
Total...	180	157	23 13	105	75 42	57	123 68
5 per cent							
P + o. w.	40	28	12 30	14	26 65	—	40 100
R + o. w.	40	29	11 27	17	23 58	3	37 93
P + t. w.	50	48	2 4	18	32 64	2	48 96
R + t. w.	50	31	19 38	8	42 84	2	48 96
Total...	180	136	44 24	57	123 68	7	173 96
7 per cent							
P + o. w.	40	12	28 70	—	40 100	—	40 100
R + o. w.	40	20	20 50	14	26 65	—	40 100
P + t. w.	50	25	25 50	—	50 100	—	50 100
R + t. w.	50	8	42 84	—	50 100	—	50 100
Total...	180	65	115 64	14	166 92	—	180 100
10 per cent							
P + o. w.	50	—	50 100	—	—	—	—
R + o. w.	50	—	50 100	—	—	—	—
Total...	100	—	100 100	—	—	—	—

larvæ died in the fifth hour; the pupæ survived 24 hours of exposure.

After 2 hours in 7 per cent salt, only 3 larvæ and 2 that pupated, out of 2,900 tested, remained alive. The 3 larvæ died in the third hour, but the pupæ survived.

During the first hour in 10 per cent salt, 1,832 (95.95 per cent) of 1,920 larvæ tested, died; one pupated. The surviving 87 larvæ died in the second hour, but the pupa still lived. Nevertheless, it did not survive 24 hours of exposure.

Regarding the effects of salt concentrations on mosquito eggs, Del Rosario (1961) reported embryonic development was prevented in eggs of *ægypti* and *albopictus* laid in 5 per cent, 7 per cent, and 10 per cent salt concentrations; but hatching occurred among eggs laid in 1 per cent and 3 per cent salt. Downs (1951), in Mexico City, reported killing of the embryos in eggs of *Anopheles aztecus*, *Anopheles albimanus*, and *Anopheles pseudopunctipennis* laid on salt concentrations higher than 0.2N to 0.3N.

Owing to the different procedures employed by previous workers in their experiments, the findings discussed in the

5, 7, and 10 per cent salt concentrations.* (For graphs, see Fig. 6.)

4-hour exposure			5-hour exposure			6-hour exposure			Next day		
Alive	Total dead		Alive	Total dead		Alive	Total dead		Alive	Total dead	
	Number	Per cent		Number	Per cent		Number	Per cent		Number	Per cent
2	38	95	-----	40	100	-----	40	100			
16	24	60	2	38	95	-----	40	100			
2	48	96	2	48	96	-----	50	100			
3	47	94	-----	50	100	-----	50	100			
23	157	87	4	176	98	-----	180	100			
-----	40	100	-----	40	100						
2	38	95	-----	40	100						
-----	50	100	-----	50	100						
-----	50	100	-----	50	100						
2	178	99	-----	180	100						

* The specimens were from pond in Araneta University compound. The tests were undertaken in the laboratory of the Araneta University.

TABLE 9.—Summary of all tests excluding those

Salt concentration	Number of larvae tested	1-hour exposure			2-hour exposure			3-hour exposure		
		Alive	Total dead		Alive	Total dead		Alive	Total dead	
			Number	Per cent		Number	Per cent		Number	Per cent
3 per cent										
<i>ægypti</i>	420	405	15	4	320	80	19	161	259	61
<i>albopictus</i>										
stream-breeders	400	398	2	0.5	316	84	21	***167	233	58
ricefield-breeders	800	649	151	19.0	382	418	52	216	384	73
pond-breeders	1100	891	209	19.0	550	550	50	235	865	79
Total...	180	157	33	13.0	105	75	42	57	123	68
5 per cent										
<i>ægypti</i>	420	302	118	28	*143	277	66	**26	394	94
<i>albopictus</i>	400	294	106	27	145	255	64	24	376	94
stream-breeders	800	439	361	45	102	698	87	14	786	98
ricefield-breeders	1100	715	385	35	231	869	79	39	1061	96
pond-breeders	180	136	44	24	57	123	68	7	173	96
Total...	2900	1886	1014	35	*678	2222	77	**110	2790	96
7 per cent										
<i>ægypti</i>	420	107	313	75	**9	411	98	**2	418	99.5
<i>albopictus</i>	400	92	308	77	15	385	96	1	399	99.7
stream-breeders	800	230	570	71	15	785	98	-----	800	100.0
ricefield-breeders	1100	344	756	69	66	1034	94	2	1038	99.8
pond-breeders	180	65	115	64	14	166	92	-----	180	100.0
Total...	2900	838	2062	71	**119	2781	95.9	**5	2895	99.8
10 per cent										
<i>ægypti</i>	420	*1	419	99.8	*1	419	99.8	*1	419	99.0
<i>albopictus</i>	400	10	390	97.5	-----	400	100.0	-----	400	100.0
stream-breeders	400	28	372	93.0	-----	400	100.0	-----	400	100.0
ricefield-breeders	600	49	551	92.0	9	591	98.5	-----	600	100.0
pond-breeders	100	-----	100	100.0	-----	100	100.0	-----	100	100.0
Total...	1920	*88	1832	95	*10	1910	99.5	*1	1919	99.5

NOTE: Each asterisk (*) represents one pupation. This is added to subsequent pupations and carried to the end of the 24-hour observations.

present paper are not strictly comparable with the results obtained by other authors. The procedure prescribed by the World Health Organization for testing the susceptibility of mosquito larvæ to larvicides (insecticides) was not yet known when MacFie (1914, 1922), Wigglesworth (1933), and Pantazis (1935) did their experiments. The experiments presented here were carried in accordance with the procedure of the World Health Organization. This involved 24-hour

for axil breeders. (For graphs, see Fig. 7.)

4-hour exposure			5-hour exposure			6-hour exposure			Next day		
Alive	Total dead		Alive	Total dead		Alive	Total dead		Alive	Total dead	
	Number	Per cent		Number	Per cent		Number	Per cent		Number	Per cent
** 82	338	80	** 46	374	89	** 3	417	99	** 2	418	99.5
***			***			***			***		
***100	300	75	***32	368	92	***10	390	98	***7	393	98
59	741	93	19	781	98	-----	800	100	-----	800	100
97	1003	91	19	1081	98	-----	1100	100	-----	1100	100
23	157	87	4	176	98	-----	180	100	-----	180	100
***1*			***			***			***		
*** **			*** **			*** **			*** **		
861	2539	88	120	2780	96	13	2827	99.5	9	2891	99.7
** 3	417	99.3	** 2	418	99.5						
1	399	99.9	-----	400	100						
1	779	99.8	-----	800	100						
5	1095	99.5	-----	1100	100						
2	178	99.0	-----	180	100						
** 12	2888	99.0	**2	2893	99.9						
** 2	418	99.5									
-----	400	100.0									
-----	800	100.0									
-----	1100	100.0									
-----	180	100.0									
** 2	2898	99.9									

observation, with hourly checking and recording of mortality, survival and pupation (if any). In all tests, too, control was provided in accordance with WHO instructions.

Some parallelisms, however, may be noted when Table 1 is compared with the results of the workers cited above. MacFie (1922) stated that in 2.3 per cent salt the larvæ of *ægypti* were rapidly killed. In the present tests, out of 420 larvæ of *ægypti* exposed to 3 per cent salt, only one larva and 2 that

TABLE 10.—*Field tests.*

Container	Treated		Estimated water content	Amount of salt added	Desired concentration	Actual content	Actual salt concentration
	Date	Time					
No. 1. Gallon ice cream can	September 26, 1961	* 3:10	cc 1,000	gm 100	Per cent 10	cc 1,550	Per cent 6.45
No. 2. Small rusty can	do.	* 3:05	80	8	10	87	9.19
No. 3 Small rusty can CONTROL	do.	* 3:10	100		Not treated		
No. 4. Truck tire	September 30, 1961	* 9:40	1,300	65	5	1,700	3.82
No. 5. Broken auto tire	October 5, 1961	* 2:30	250	12.5	5	837 Rained heavily during the night.	1.49

Observations			
First	Second	Third	Final
September 27, 1961, 6:00 a.m., (with flashlight) 5 adults resting at side of can escaped when observer attempted to catch them. 2 emerging. All larvae apparently dead, but some pupae alive and active.	10:00 a.m., emerging adults seen at 6:00 a.m.; died without completely getting out of pupal skin. 1 adult caught on water surface (evidently newly emerged)—♀ <i>albopictus</i> . Some pupae still alive.	1:20 p.m. 2 newly emerged adults caught on top of water 1♂ and 1♀ <i>albopictus</i> . Some pupae still alive.	3:10 p.m.: All pupae isolated in breeding jar with "salted" water, placed under lantern chimney. At different hours, on September 27 and 28, emerged into adults—total 8 males, 12 females, <i>albopictus</i> . Larvae preserved and identified later as: <i>egypti albopictus</i> 1st instar .. 0 0 2nd instar .. 9 21 3rd instar .. 7 13 4th instar .. 1 0 Total .. 17 34 4:05 p.m. As of 10:15 a.m.
September 27, 1961, 6:20 a.m. All larvae dead and 2 pupae alive.	10:15 a.m. All larvae dead; 1 adult emerged (♀ <i>albopictus</i>) the other pupa died (identified, ♀ <i>albopictus</i>).	2:20 a.m. All alive	4:10 p.m. 1 emerged (♂ <i>albopictus</i>). 7 4th instar larvae alive. No pupae.
September 27, 1961, 6:30 a.m. All larvae and pupae alive.	10:25 a.m. All alive. 1 pupa emerged into ♀ <i>albopictus</i> .		
September 30, 1961, 12:12 p.m. (with flashlight, as the tire was very well shaded). All larvae and pupae moving wildly as if affected. None dead.	5:00 p.m. (with flashlight). Several adults (probably newly emerged) flew away as light disturbed them. A few larvae were dead. The rest of the pupae and larvae were no longer restless.	October 1, 1961 7:10 a.m. (with flashlight) dead larvae afloat and at bottom about 50 per cent of total larvae. Remaining larvae weak, and dying.	October 2, 1961, 9:40 a.m. (with flashlight). Adults flew away as light struck them. All larvae dead. Several pupae still alive. These were isolated; emerged into adults at different hours October 2 and 3. 1 - ♀ <i>egypti</i> , 9♂, 20♀ <i>albopictus</i> = Total 30 adults. Dead larvae identified: <i>w- alb- fati- gyp- pic- gans ti tus</i> 1st instar .. 0 0 0 2nd instar .. 21 27 4 3rd instar .. 2 15 8 4th instar .. 0 1 3 Total 23 43 15 Alive larvae taken and identified: (2:30 p.m.). 1st instar .. 0 0 14 2nd instar .. 21 15 39 3rd instar .. 14 10 38 4th instar .. 10 7 22 Total 45 42 104 Dead larvae: 1st instar .. 0 0 0
October 6, 1961, 8:00 a.m. Caught from water surface and sides of tire, <i>egypti</i> , 5♂♂ and 6♀♀; <i>albopictus</i> , 4♂♂; <i>fati-gans</i> , 2♂♂ and 16♀♀. A few dead larvae. Many alive larvae and pupae.	Not done.	Not done.	

TABLE 10.—Field tests—Continued.

Container	Treated		Estimated water content	Amount of salt added	Desired concentration	Actual content	Actual salt concentration
	Date	Time					
No. 5. Broken auto tire			cc	gm	per cent	cc	per cent
No. 6. Tin can (Control, not treated.)	October 5, 1961	* 3:00	200			Rained during the night. Exact amount full to the brim probably overflowed due to the rains.	
No. 7. Coconut shell (a)	October 14, 1961	* 9:45	100	10	10	83	12.05
No. 8. Coconut shell (b)	do	** 9:50	200	30	10	330	9.99
No. 9. Coconut shell (c)	do	** 9:55	200	20	10	150	13.33
No. 10. Pineapple tin can slightly rusty	October 14, 1961	** 10:00	80	8	10	78	10.25

Observations			
First	Second	Third	Final
October 6, 1961, 8:10 a. m. Adults taken from water surface and sides of can. 4 ♂♂ <i>fatigans</i>. All larvæ and pupæ alive. October 14, 1961, 10:45 a. m. 12 larvæ dead, 2 larvæ dying, and 1 pupated. October 14, 1961, 11:55 a. m. All 21 larvæ dead and 1 pupa alive. Larvæ picked out and preserved. Pupa isolated in "salted" water. October 14, 1961, 12:00 noon. Only 3 larvæ. All dead: <i>albopictus</i>. 3rd instar..... 1 4th instar..... 2 Total..... 3 October 14, 1961, 1:00 p. m. All six larvæ dead identified as: <i>albopictus</i>. 2nd instar..... 4 3rd instar..... 2 Total..... 6	None made. 1:00 p.m. All 14 larvæ dead, picked out, and preserved. Pupa alive. 1:10 p.m. Pupa still alive.	None made. 3:00 p.m. Pupa still alive. 3:20 p.m. Pupa still alive.	<i>x- albo- fati- gyp- pic- gans</i> <i>ti tus</i> 2nd instar.. 0 0 0 3rd instar.. 4 3 0 4th instar.. 2 2 2 Total.... 6 5 2 Pupæ taken and isolated emerged into: 3 ♂♂ <i>egypti</i>; 1 ♂, <i>albopictus</i>; 1 ♀, <i>fatigans</i>. 3:02 p.m. Larvæ and pupæ alive. Pupæ taken and isolated; became: 7 ♂♂, 17 ♀♀ <i>egypti</i>; 1 ♀, <i>albopictus</i>; 1 ♂, 4 ♀♀ <i>fatigans</i>. Larvæ identified: <i>x- albo- fati- gyp- pic- gans</i> <i>ti tus</i> 1st..... 0 0 3 2nd..... 2 2 2 3rd..... 4 1 3 4th..... 1 3 4 Total.... 7 6 12 October 15, 1961, 9:45 a.m. Pupa still alive. Isolated in "salted" water. Became adult: ♂ <i>albopictus</i>. Dead larvæ identified: <i>x- albo- egypti pic- tus</i> 1st instar.... 0 0 2nd instar.... 3 2 3rd instar.... 2 5 4th instar.... 1 1 Total..... 6 8 October 15, 1961, 9:50 a.m. Pupa died, identified as ♀ <i>albopictus</i>. Larvæ: all <i>albopictus</i>; 1 instar.... 12 2nd instar.. 6 3rd instar.. 3 4th instar.. 0 Total.... 21

TABLE 10.—*Field*

Container	Treated		Esti- mated water content	Amount of salt added	Desired concen- tration	Actual content	Actual salt concen- tration
	Date	Time					
No. 11. Coconut shell (d) CONTROL	...do...	** 10:00	200	Not		Treated	

pupated remained after 5 hours. The larva died in the seventh hour; but the pupæ survived in the medium and became adults after more than 24 hours. MacFie (1922) claimed that 50 per cent sea water (about 1 per cent salt) killed all *ægypti* larvæ he tested within 24 hours of exposure. However, Wigglesworth (1933) said 48 hours' exposure in 1.4 per cent salt was necessary to kill them.

Preliminary tests in artificial containers.—Field tests in artificial containers, using only raw salt from Las Piñas, were conducted at Tala during September and October, 1961, when rains were heavy and mosquito-breeding in artificial containers was high. The procedure was the same as that used in the laboratory, but the water in each container was merely estimated, and an accurately weighed amount of salt was added according to the percentage of salinity desired. In actual field operations, it would be impractical, time-consuming and often impossible to measure the exact amount of water in each container.

Different amounts of salt were weighed and wrapped in paper. The amount was written on each paper wrapper. When the water content of a container had been calculated, a portion of the water, minus the larvæ and pupæ, was pipetted into a small beaker, and the pre-weighed salt dissolved in it. Then the solution was poured back into the breeding container and gently stirred with a glass rod to homogenize the resulting salt solution. Stirring was done in such a way that it did not hurt either larvæ or pupæ.

tests—Continued.

Observations			
First	Second	Third	Final
<i>albopictus</i> 2nd instar 4 3rd instar 2 Total 6 October 14, 1961, 12:00 noon. All alive.	1:15 p.m. All alive.	3:25 p.m. All alive.	October 15, 1961, 12:00 noon. All alive, taken, killed and identified later as: <i>x. albo-</i> <i>gypti pic-</i> <i>tus</i> 1st instar 1 0 2nd instar 2 1 3rd instar 1 2 4th instar 2 1 Total 6 4

Checkings were not made hourly, but only twice or more before the 24th hour. In these preliminary field tests, the following procedure was observed in order to find how good it might be. After the 24th hour the entire contents of each container, including the larvæ and pupæ, were transferred into a graduated cylinder for measurement of the water; then this was carefully poured into a white enamel basin or bowl. The living pupæ, if any, were transferred into isolation jars and placed under a lantern chimney, the top end of which was covered with *sinamay* cloth. The isolation jars contained the "salted" water. The pupæ were left there until they either died or emerged into adults. The dead larvæ were collected and identified immediately when possible, or preserved and identified later. The living larvæ, if any, were killed and also identified.

Eight different artificial containers were tested; three others were used as control. The results are shown in Table 10.

SUMMARY AND CONCLUSION

1. Laboratory tests on the use of salt concentrations of 3, 5, 7, and 10 per cent, and field tests on the use of concentrations of 1.49, 3.82, 6.45, 9.19, 9.99, 10.05, 10.25, and 13.33 per cent against the breeding of mosquito larvæ were made. The laboratory tests consist of two parallel series; chemically pure salt concentrations and similar concentrations of unpurified Las Piñas salt. In the field, only concentrations of raw Las Piñas salt were used. The tests involved 10,945 larvæ in the labora-

tory and 401 in the field. The laboratory results showed no material differences between concentrations of pure and raw salts.

2. Accurately measured water and salt and selected and counted larvæ were used in the laboratory. In the field, the breeding water in each container was merely calculated and the salt, accurately weigh, added according to the degree of concentration desired. The specimens tested were whatever were found breeding in the container. After 24 hours the breeding water was measured and the actual salt concentrations were computed. The intended concentrations in field tests were only 5 per cent and 10 per cent. The results, however, varied from 1.49 to 13.33 per cent.

3. In the laboratory tests, as in the field, concentrations of 10 per cent or thereabouts registered complete kill of all larvæ within one or two hours of exposure. But, while 3 per cent salt in the laboratory consistently killed all larvæ in 5 or 6 hours, in one field test (using 3.82 per cent salt) most of the larvæ were still alive after 7½ hours' exposure; complete kill occurred during the night as shown by the final checking the next morning.

4. No laboratory tests for salt less than 3 per cent was undertaken. A field-test salt concentration originally calculated to be around 5 per cent but which was later reduced by rains to only 5 per cent but which was later reduced by rains to only 1.49 per cent had no effect on the larvæ. Out of 204 larvæ exposed in this test, 13 or 6.37 per cent were killed. It seems probable that the deaths occurred before the rains lowered the concentration of salt.

5. Among axil breeders, the first- and second-instar larvæ were evidently less susceptible to salt than the third- and fourth-instars.

6. Pupation occurred in different concentrations in laboratory tests; probably also in field tests. Ten per cent or more salt concentrations apparently had little or no effect on pupæ.

From the foregoing it may be concluded that 10 per cent Las Piñas salt may be effectively used against mosquito-breeding in artificial containers; primarily against *Aedes ægypti* and *Aedes albopictus*, both of which are transmitters of diseases. However, the application of salt during the rainy season, when breeding of these two species is at its peak,

should be timed between rains so that the concentration may not be lowered and rendered ineffective. The addition of salt should err towards the higher (more effective) concentration.

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TAXONOMY DISTRIBUTION AND SEASONAL OCCURRENCE OF EDIBLE MARINE ALGÆ IN ILOCOS NORTE, PHILIPPINES

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NINE PLATES AND ONE TEXT FIGURE

From time immemorial man has utilized marine plants as a supplement to cover his food needs. Among the Asiatics, particularly the Chinese, Japanese, and Malays, seaweeds are valued highly as food of great delicacy. In the Philippines, where 570,000 square miles of seas surround the 7,100 islands, the people have long been using seaweeds or algæ as part of their daily diet. In Ilocos Norte Province, in particular, over 19 species are known to be edible. Of these no less than ten are being sold commercially. The Ilocanos consume them as salads or pickles or cook them into omelets.

Seaweeds are also known to be eaten similarly in Pangasinan Province, the Cagayan Valley, La Union Province, and the Bicol Region. In the Visayan Islands and the coasts of Mindanao, seaweeds are also reported eaten boiled or mixed with other vegetables [Collado (1926)]. Farther south and southwest, in Palawan and the Sulu Archipelago, algæ in season are always being sold in the market.

Seaweed production the world over increases continuously on account of the constant seepage of nutrients from the land to the sea. The rains leach these substances from the soil, where many of them play important roles in the food synthesis of green plants. Marine algæ, which are as autotrophic as flowering land plants, possess chlorophyll and this enables them to manufacture sugar by photosynthesis. In the same manner, sugar is elaborated into various food compounds in the presence of organic and inorganic nutrients in the sea.

A survey is useful in determining which of the local marine algæ have definitely high food values and, therefore, are suitable for widespread utilization by the country's fast growing population. The purpose of this investigation was, thus, to gather definite information about the species used as food in the coastal towns of Ilocos Norte Province, to furnish data

about their relative abundance and distribution during different seasons of the year, and to establish their taxonomic position in the seaweed group.

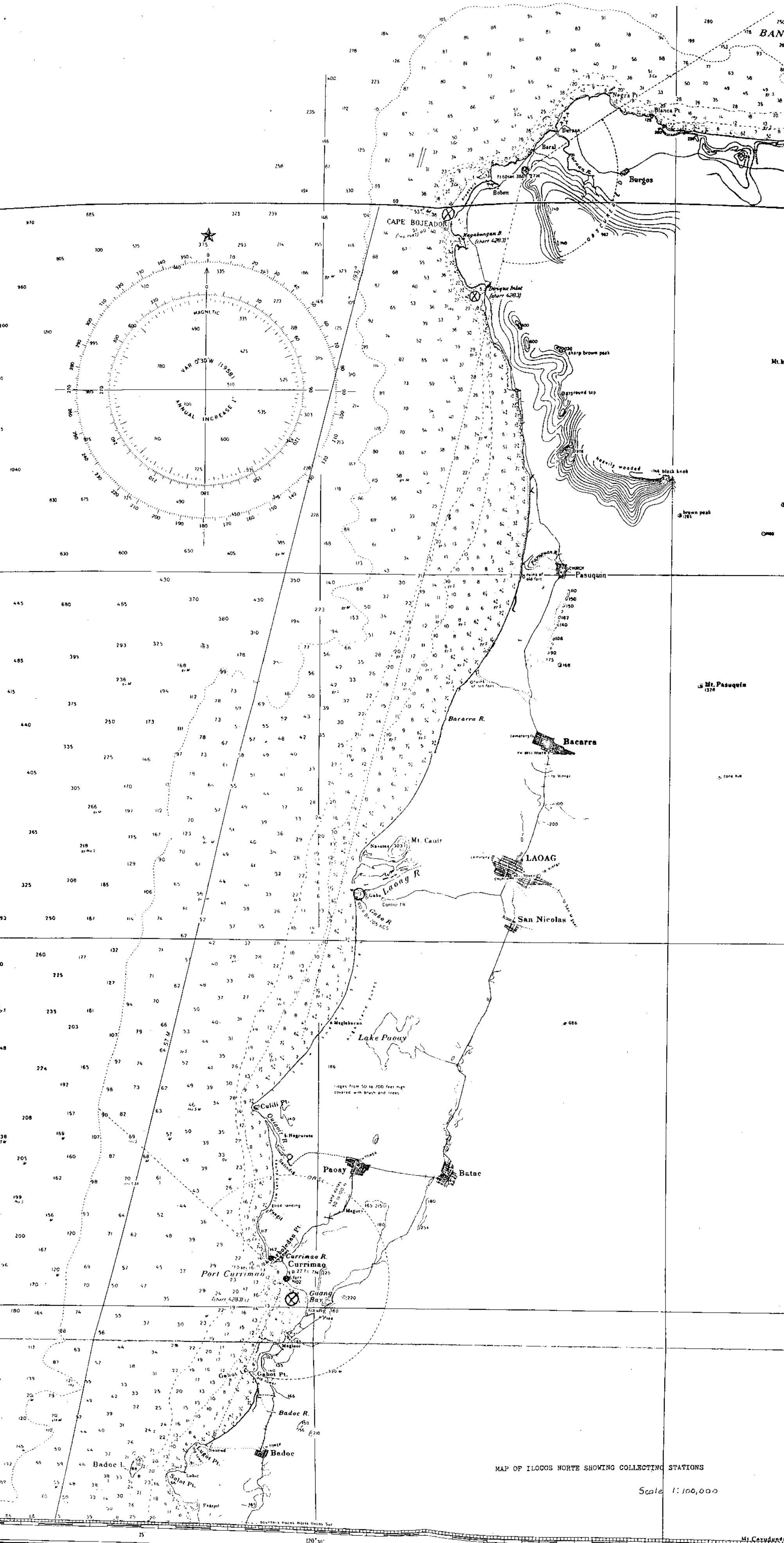
REVIEW OF LOCAL LITERATURE

The earliest mention of Philippine algæ was made in the first edition of Fr. Manuel Blanco's *Flora de Filipinas* (1837). George von Martens (1866) referred to Blanco's work when he enumerated the Philippine species; but he made no mention of the edible ones. Seale (1911), in an attempt to stimulate interest on the subject, reported 11 edible seaweeds sold in Manila markets. Wells (1916), on the other hand, found that *gulaman dagat*, which is being sold in the Philippines as a substitute for gelatin, is low in nutritive constituents.

In view of the abundance of seaweeds, Collado (1926) studied the nutritive properties of the edible species of *Gracilaria confervoides* (*guraman*), *Laurencia* sp. (*culot*), and *Sargassum* sp. (*aragan*), which were collected from a brackish stream in Buguey, Cagayan Province. His study shows that *G. confervoides* has the highest carbohydrate content; followed by *Laurencia* and *Sargassum* species, the second and third highest respectively. Fourteen other edible marine algæ in the region were also studied.

Sulit (1952) reported that along the shores of Burgos (Ilocos Norte) and Claveria and Aparri (Cagayan) *Porphyra*, a seaweed known as *gamet*, was found abundant. Montilla and Blanco (1952) reported 25 species known to be edible and medicinal in the Philippines. These were presumably collected from the Ilocos Region because the common names were in the Ilocano dialect.

Velasquez (1948) made a survey of the possibility of using seaweeds as part of the daily diet of Filipinos and of agricultural animals. The development of a "seaweed meal" for cattle or a seaweed substitute in the ration of hogs and fowls could be another possible use of the plants and encourage the building of a new industry. The people of other countries, especially those of Japan, China, and of the coasts of Europe and the Americas have long utilized seaweeds for the production of agar. Commercial products, derived from them such as alginates and carageenin, have long been known in world markets.



LOCALITY

The province of Ilocos Norte occupies the whole of the coastal plain of the northwestern corner of Luzon Island, Philippines, between latitudes $17^{\circ} 54'$ and $18^{\circ} 35'$ North and longitudes $120^{\circ} 27'$ and $120^{\circ} 50'$ East. It is accessible by bus and plane, being only 533.4 kilometers north of Manila. Its coastline starts on a rocky shore at Pasaleng Bay, facing the Babuyan Channel, and slopes ruggedly westward, then southward facing the China Sea.

The coastal towns are composed of numerous flatlying lands, whereas towards the sea, the shoreline is indented with a number of sandy-rocky coves of various sizes. Several promontories fringe the coastline. The irregular indentation and varied topography make the place excellent for the growth of marine algæ. Pronounced wet and dry season characterize the climate. Rain comes from May to October and dry the rest of the year.

Collecting stations.—Collections were made along the coasts of Burgos, Pasuquin, and Currimaos. The first represents the northernmost collection station; whereas the last, the southernmost. They are 40 nautical miles apart. Two barrios of Burgos, Bubon and Buraan, have been included. The former was divided into Bubon I and Bubon II for collection purposes. This made a total of five collecting stations as indicated on the map (see Fig. 1).

The species collected in these stations at different dates and their relative abundance are shown in Table 1; their relative abundance in months, as gathered from observations of the people along the coasts, is given in Table 2.

Bubon I is a sheltered indentation located north-northeast, in the vicinity of Cape Bojeador. Big boulders predominate the northernmost side, abruptly rising to a flat rolling elevation of considerable height, usually barren except for the growth of a few dwarfed species of vascular plants. This surf-beaten part of the coast leaves sea water in numerous tide pools ranging in depth from the ankle to a little above the waistline. Species of *Porphyra* and *Enteromorpha* abound in these tide pools. They occur as patches in association with other red algæ. *Enteromorpha* species oftentimes fills a single large pool. A large expanse of tidal flat characterizes the intertidal zone in this station. Other algæ cannot grow much owing

TABLE 1.—Relative abundance of the marine edible algae of Ilocos Norte

Specimens	Bubon					
	Bubon I				Bubon II	
	Decem- ber 28, 1959	April 28, 1960	August 2, 1960	Novem- ber 18, 1960	Decem- ber 29, 1959	April 28, 1959
1. <i>Enteromorpha plumosa</i> Kützting	XX			X		
2. <i>Enteromorpha compressa</i> (Linn.) Greville	XXX					
3. <i>Ulva lactuca</i> Linn.	XXX	XXX	X	XXX	XXX	
4. <i>Caulerpa racemosa</i> (Forsskål) J. Agardh var. <i>clavifera</i> (Turn.) Weber van Bosse	XXX	XX	XX		XXX	
5. <i>Codium papillatum</i> Tseng and Gilbert	XXX	XXX				
6. <i>Codium</i> sp.	XXX	XXX	XXX			XX
7. <i>Codium intricatum</i> Okamura	X	XXX		X		
8. <i>Hydroclathrus clathratus</i> (Bory) Howe	X	XXX		XX	XX	
9. <i>Porphyra crispata</i> Kjellman	XXX	XX		XXX		
10. <i>Gelidium acerosa</i> (Forsskål) Feldman and Hamel	XXX	XXX	X		XXX	
11. <i>Hatymenia durvillaei</i> Bory		XXX				
12. <i>Enchema muricatum</i> (Gmelin.) W. v. B.		XXX				
13. <i>Hypnea chroides</i> Lamouroux	X	X	XXX	XXX	XX	
14. <i>Gracilaria salicornia</i> C. Ag.	XX	XX				
15. <i>Gracilaria verrucosa</i> (Huds.) Papenfuss	XX	XXX			X	
16. <i>Gracilaria coronopifolia</i> J. Agardh	XX	XXX	XX		X	
17. <i>Laurencia papillosa</i> (Forsskål) Greville	XXX	XXX	X	XXX	XXX	
18. <i>Laurencia okamurae</i> Yamada	XXX	XX	X	XXX	XX	
19. <i>Acanthophora spicifera</i> (Vahl.) Borg	XXX	XX	X	XXX	XXX	

TABLE 2.—Monthly availability of marine algae of Ilocos Norte.

Specimens	Common name	January	February	March
1. <i>Enteromorpha plumosa</i> Kützting	Lumot	XXX	XXX	XXX
2. <i>Enteromorpha compressa</i> (Linn.) Greville	Lumot			
3. <i>Ulva lactuca</i> Linn.	Gamgamet	XX	XX	XX
4. <i>Caulerpa racemosa</i> (Forsskål) J. Agardh var. <i>clavifera</i> (Turn.) Weber van Bosse	Ararucip	XXX	XXX	XXX
5. <i>Codium papillatum</i> Tseng and Gilbert	Pocpoclo	XX	XXX	XXX
6. <i>Codium</i> sp.	Pocpoclo	XXX	XXX	XXX
7. <i>Codium intricatum</i> Okamura	Pocpoclo			
8. <i>Hydroclathrus clathratus</i> (Bory) Howe	Balabalang	XX	XX	XXX
9. <i>Porphyra crispata</i> Kjellman	Gamet	XXX	XXX	XX
10. <i>Gelidium acerosa</i> (Forsskål) Feldmann and Hamel	Culot	XXX	XX	XX
11. <i>Hatymenia durvillaei</i> Bory	Gayong-gayong		XX	XX
12. <i>Enchema muricatum</i> (Gmelin.) W. v. B.	Canot-canot			
13. <i>Hypnea chroides</i> Lamouroux	Culot ti pusa			
14. <i>Gracilaria salicornia</i> C. Ag.	Canot-canot			
15. <i>Gracilaria verrucosa</i> (Huds.) Papenfuss	Caocaoayan	XXX	XXX	XXX
16. <i>Gracilaria coronopifolia</i> J. Ag.	Caocaoayan	XX	XX	XX
17. <i>Laurencia papillosa</i> (Forsskål) Greville	Culot	XXX	XX	XX
18. <i>Laurencia okamurae</i> Yamada	Culot	XXX	XX	
19. <i>Acanthophora spicifera</i> (Vahl.) Borg	Culot	XXX	XXX	XXX

Legend: X, rare; XX, fairly abundant; XXX, very abundant.

collected from five stations, December 28, 1959 to November 19, 1960.

Bubon			Currima			Pasuquin		
Bubon II	Buraan		Gaang Bay			Dirique Inlet		
November 18, 1960	August 3, 1960	November 19, 1960	April 26, 1960	August 1, 1960	November 20, 1960	April 27, 1960	August 2, 1960	November 13, 1960
X								X
X						X	XXX	
XXX								
XXX		X			X			
X	XX	XX	XXX				X	
XXX		XX	XX				X	
		XXX	XX		XXX			
XXX						X		
XXX	XXX	XXX		XX	XXX			
XXX			XX		XX	XXX		
XXX	XX					XXX		
XXX							XXX	
XXX		XXX	XXX		XXX			

April	May	June	July	August	September	October	November	December
XXX	XXX						XX	XXX
							XXX	XX
				XX	XX	XX	XX	XXX
XX							XX	XX
XXX	XX						XX	XX
XXX	XX							
XXX							XX	XX
							XXX	XXX
XX								
XXX				XXX	XXX	XXX	XXX	XXX
XXX							XX	XXX
XX							XXX	XXX
XX							XX	XXX
XXX	XX						XX	XXX

to sand deposits fixed by the waves. In the upper intertidal zone is an abundant growth of *Ulva* usually exposed during low tides. Towards the deeper portions of the shore, excellent growth of *Codium* could be gathered in large quantities by diving at a depth of about 10 to 15 feet. *Codium* sold in abundance in the markets of many towns in the province is gathered from this place.

One and a half kilometers farther south is Bubon II. The coast has a uniform appearance ending in a small promontory of narrow, flat, coral reef entirely exposed during low tide. Abundant *Gracilaria*, associated with *Thalassia* and *Caulerpa racemosa* var. *clavifera*, is collected at a depth of about 10 feet. *Gelidiella*, *Hypnea*, *Laurencia*, and *Acanthophora* species also grow abundantly.

The barrio of Buraan is 5 km. north of Bubon and 39 km. north of Laoag, the capital of Ilocos Norte. The water is brackish on a rocky substratum sprinkled promiscuously with generally fist-sized stones. The rocky boulders are overgrown with *Enteromorpha*, *Hypnea* and *Gelidiella* species, which intermix with growths of *Acanthophora* and *Padina*. The shoreline goes forward further west and slopes southward towards the direction of Bubon. The stratum becomes sandy-rocky and water is waist-deep with species of *Codium* and *Caulerpa*. Fields of brownish-red, erect growth of *Acanthophora* occur in the upper intertidal zone and lie exposed during ebb tides.

Dirique Inlet is a sheltered indentation in the town of Pasuquin, 33 km. north of Laoag and 6 km. south of Bubon. A narrow reef is located in the south side where a few *Gracilaria* species grow. The northwest shore is high and rugged, and composed of much broken, usually eroded, rocks. It has a narrow, gently sloping shoreline below, where *Halymenia* grows on big boulders neck deep at low tide. *Laurencia* occurs at the shallower portion of the shore. Cast *Codium* could be found drifting with fronds of *Sargassum*, especially after a high wind.

Near the southern boundary of Ilocos Norte, 24 km. south of the capital, is Gaang Bay in the town of Currimaos. The shoreline on the northeast boundary has an almost abrupt depth where *Hypnea* is abundantly attached to rocks, often exposed during low tides. Farther south is a wide expanse of tidal flat dotted with brown patches of *Sargassum* in the

deeper portion. Narrow, deep, tide pools in the form of rivulets lie in parallel formations, the level of the water depending on the ebb and flow of the tide. An abundance of *Galaxaura* and *Liagora* species is at the bottom of these formations. On the upper intertidal zone at ankle depth during low tide is to be found *Gracilaria salicornia* overcast with calcareous deposits. *Codium* is to be found at times on the rough surfaces of rocks. An abundance of *Gelidiella* and *Acanthophora* species, growing together on submerged rocks with some *Gracilaria*, predominates the area.

HABITAT

Habitats of the algæ.—The sea affords two distinct habitats for the benthic algal flora; namely, (1) the part of the shore that is daily exposed during low-tide periods, and (2) the more extensive region below low-water mark where the algal vegetation always remains submerged. These regions, designated as littoral and sublittoral zones, respectively, offer different environmental conditions and bring about the growth of a variety of species of the seaweed population [Fritsch (1945)]. A third one, the spray zone, extends above the upper littoral, where the algæ are reached only by sprays of sea water produced by high winds or are slightly submerged during exceptionally high tides. Feldmann (1951) calls this the "supralittoral zone." The collecting stations visited could well be similarly classified as supralittoral, littoral, and sublittoral.

The habitats of the algæ collected are as follows: (1) rocky shores and boulders, (2) sandy-rocky substrata with a thin layer of mud, (3) stony, brackish mouth of river, and (4) the narrow, long blades of *Thalassia*. A marina grass *Thalassia*, grows densely in shallow sandy depressions. The epiphytic *Hypnea charoides* is attached in small groups near the tips of its narrow leaves. No edible species were collected along the mangroves.

Some of the algæ of the littoral zone are exposed at low tide; while others, especially *Enteromorpha* and *Ulva*, find shelter in rock pools with little water. Sandy substratum abounds mostly in species which can bind the sand together in order to obtain a firm holdfast. On the rocky coast near Cape Bojeador, a few algæ, dominated by *Porphyra crispata*, occur

far above the normal high-water mark where they can be reached only by exceptional high-tide during stormy weather. This elevated habitat is the supralittoral, or spray zone. An association of *Acanthophora-Gelidiella-Laurencia* species is found in crevices of big boulders. Stony brackish mouths of rivers are abundant in *Hypnea-Gelidiella* association. *Gracilaria verrucosa* grows with *Thalassia* in a sandy-rocky substratum. *Codium* prefers the sandy-rocky depths of the sublittoral zone with a thin layer of mud.

MATERIALS AND METHODS

Collection and preparation of materials.—Collection of the marine edible algæ in the province of Ilocos Norte began during the Christmas vacation of 1959 in Bubon, Burgos. This first collection proved Bubon to be the riches of all the collecting grounds visited henceforth. Succeeding collection trips were made at intervals of every four months for a period of one year. The last collection was done during the month of November, 1960. Bubon II in Burgos, Dirique Inlet in Pasuquin, and Gaang Bay in Currimaos were visited three times. These collecting stations were suggested by the mayors of the coastal towns, who furnished the authors information about the edible algæ of the province. (Table 3.)

Collection was done at low tide as determined by the Tide and Current Tables issued by the Bureau of Coast and Geodetic Survey. In collecting, a 10-pound pail, wide-mouthed bottles for small and delicate algæ, a glass-bottom box, and a pocket knife for detaching some algæ on rocks were used. For protection from barnacles and sharp edges of rocks each collector wore shoes that fitted above the ankles. A long-sleeved shirt and a light pair of overalls or long pants also gave protection from overexposure to intense sunlight and poisonous organisms. Only living, complete specimens were collected, studied, and cured for herbarium purposes, as suggested by Taylor (1945).

Laboratory observations.—The habits of each species were recorded in photographs and their anatomical structures studied and reproduced by camera-lucida drawings. Temporary glycerin mounts of sections were made whenever more time was needed for their study. As much as possible a uniform magnification for all the illustrations was maintained to show relative sizes of different structures.

TABLE 3.—Summary of information about edible marine algae furnished by the mayors of the coastal towns of Ilocos Norte.

Algae	Source municipality	Month of the year in abundance	How eaten	Remarks
Pocpoco (<i>Codium</i> spp.)	Badoc Currimao Burgos Pagudpud Pasuquin Paoay	January to April December to March January to May March to April February to May	raw raw raw raw raw	no information
Culot (<i>Gelidiella acerosa</i> , <i>Laurencia papillosa</i> , <i>L. okamurai</i> , <i>Acanthophora spicifera</i>)	Badoc Burgos Currimao Pagudpud Pasuquin Paoay	Any month November to February September to December December to January Any month June to August	raw or cooked raw or cooked raw or cooked raw or cooked raw or cooked dried or fresh	
Ararueip (<i>Caulerpa racemosa</i> var. <i>clavifera</i>)	Badoc Burgos Currimao Pagudpud Pasuquin Paoay	January to March November to January November to April March September to December June to August	raw raw raw raw raw raw	
Gamet (<i>Porphyra crispata</i>)	Badoc Burgos Currimao Pagudpud Pasuquin Paoay	December to March November to December November to January	raw or cooked, etc. raw or cooked raw or cooked	none none none
Lumot (<i>Enteromorpha</i> spp.)	Badoc Burgos Currimao Pagudpud Pasuquin Paoay	April to May January to April November to December June to August	raw raw or cooked raw or cooked raw or cooked	no information no information
Balbalulang (<i>Hydroclathrus clathratus</i>)	Badoc Burgos Currimao Pagudpud Pasuquin Paoay	February to March December to April March to May June to August	cooked raw cooked	none none

TABLE 3.—Summary of information about edible marine algae furnished by the mayors of the coastal towns of Ilocos Norte—Continued.

Algae	Source municipality	Month of the year in abundance	How eaten	Remarks
Gayong-gayong (<i>Halymenia durvillaei</i>)	Badoc	January to March	cooked	none
	Burgos			none
	Currimao	February to April	raw or cooked	none
	Pagudpud			
	Pasquin			
Gargararao (<i>Gracilaria</i> spp.)	Paoay	February to May	raw or cooked	none
	Badoc			
	Burgos	November to January	raw or cooked	none
	Currimao			Caocayaan
	Pagudpud			Maracaayan
Canot-canot (<i>Eucheuma muricatum</i>)	Pasquin	December to February	raw or cooked	Curaman
	Paoay	September to December	raw or cooked	Curaman
	Badoc	June to August	raw or cooked	Gurguraman
	Burgos	November to January	cooked	no information
	Currimao			no information
Lab-labig (Species not determined)	Pagudpud	March to April	cooked	no information
	Paoay			
	Badoc	January to April	raw or cooked	Laplapig
	Burgos	December to February	cooked	no information
	Currimao	December to January	cooked	no information
Gargarnatis (Species not determined)	Pagudpud			
	Pasquin	January to March	raw or cooked	no information
	Badoc	December to January	raw	
	Paoay	April to May	raw	
Bangi (Species not determined.)	Burgos	November to March	raw or cooked	not available in the market
	Pagudpud	December to February	raw or cooked	
Samsamit (Species not determined.)	Burgos	May to August	cooked	
Aragan (<i>Sargassum</i> sp.)	Pagudpud	February to May	cooked	
Baris-baris (<i>Liagora</i> sp.)	Pasquin	November to December	raw	
Panpanao (Species not determined.)	Paoay	June to August	raw or cooked	

Keys and descriptions of species

This work includes 19 species belonging to 13 genera, 11 families, and 8 orders. Of these one variety has been found under class Chlorophyceæ.

Key to classes

- | | |
|--|--------------|
| 1. Pigmentation of unmasked chlorophyll | Chlorophyceæ |
| 1. Chlorophyll masked by accessory pigments | 2 |
| 2. Fucoxanthin dominant as brown accessory pigment. | Phaeophyceæ |
| 2. Phycoerythrin dominant as red accessory pigment. | Rhodophyceæ |

Class CHLOROPHYCEÆ

Plants belonging to this class are unicellular or multicellular: colonial or united in simple aggregate to form branched or unbranched filaments, or macroscopic thalli of indefinite shape. They may be attached or free floating. The chief distinguishing characteristic is the presence of grass-green chloroplast composed of chlorophyll a and b associated with carotene and xanthophyll present in the same proportion as the higher plant. They occur singly or in abundance in each cell, the shape depending upon the genus or species. Pyrenoids usually are present and starch is the common reserve food. Cell wall is of cellulose and pectic compounds. Reproduction is by asexual and sexual methods. They are commonly abundant in fresh-water habitats though some orders are well represented in marine habitats.

Key to the orders

- | | |
|---|------------|
| 1. Vegetative body foliaceous, expanded or tubular with crosswall. . . | Ulvales |
| 1. Vegetative body foliaceous, expanded or tubular with cross walls present only in reproductive structures | Siphonales |

Order ULVALES

Plants are thalloid nearly always attached by rhizoids which are free or differentiated into a holdfast. Fronds are usually multicellular, foliaceous; tubular or flat, of one to two cell layers. Cells are mostly uninucleate, with a single rarely two or three parietal chromatophores and one or more pyrenoids. Asexual reproduction by bi- or quadriflagellated zoospores, akinetes or aplanospores. Sexual reproduction by two- or four-flagellated iso- or anisogametes; rarely by oogamy.

Key to the genera

- | | |
|--|---------------------|
| 1. Frond tubular, at least in part, of a single cell layer.... | <i>Enteromorpha</i> |
| 1. Frond expanded, of 2-cell layers | <i>Ulva</i> |

Genus ENTEROMORPHA Link, 1820

Fronds are persistently tubular throughout except for uniseriate branch tips in some species. They may be simple proliferous or repeatedly branched, usually slender and more or less cylindrical or clavate, inflated or compressed. The walls of the tubular fronds are of a single-cell layer. Cells uninucleate containing a single cup-shaped or laminate chloroplast and a pyrenoid. Multiplication of the thallus takes place by fragmentation and proliferation; asexual reproduction by quadriflagellated zoospores or biflagellated gametes, the formation takes place in any but the basal cells.

Key to the species of *Enteromorpha*

1. Cells subrectangular, more or less in longitudinal series in greater part of the frond; branch tips ending in a uniseriate row of cells. *E. plumosa*
1. Cells angular, irregularly placed; branched tips not ending in a uniseriate row of cells *E. compressa*

ENTEROMORPHA PLUMOSA Kützinger.

Enteromorpha plumosa Kützinger in GILBERT (1942a) 30-31; TOKIDA (1954) 53, Pl. 4, figs. 11-16.

Plant attached, light green, with a small disc-shaped holdfast. Thallus filiform, delicate irregularly or sometimes in part oppositely branched; branches tapering at the base, usually with long uniseriate tips or relatively short and monosiphonous for their entire length. Cells subrectangular, more or less arranged in longitudinal rows, 10.8 to 25.2 μ wide and 18.0 to 32.4 μ long. The width of the monosiphonous parts ranging from 12.6 to 25.2 μ wide.

Spores present in ordinary vegetative cells, Plate 1, fig. 1a.

Descriptive material collection No. 1.

Collections: Bubon I, Burgos: luxuriant green growth on tide pools on rocky substratum reached by spray of big waves, 1, December 28, 1959; young growth on rocks exposed on the shore, 101a, November 18, 1950.

ENTEROMORPHA COMPRESSA (Linn.) Greville. Plate 1, figs. 1a-c; Plate 6, fig. 19.

Enteromorpha compressa Greville in SMITH (1944) 52.

Plant attached, bright to dark green, with a small disc-shaped holdfast. Thallus tubular, branches arising from a gradually contracted stalk-like base entirely similar to the principal blade; narrow at the base gradually expanding above with a broadly

expanding apex. Cells angular, irregularly arranged, 10.3 to 28.8 μ wide, and 18.0 to 32.4 μ long, walls not thickened.

Descriptive material collection No. 1a.

Collection: Bubon I, Burgos: found attached to and submerged on rock pools with *E. plumosa* exposed to occasional splashes of big waves and strong wind, 1a, December 28, 1959.

Genus *ULVA* Linneaus, 1753

Plants expanded, marginally attached or substipitate plane or crispate, lobed or elongate-laciniate; of two-cell layers. Cells with a single chromatophore with one or two pyrenoids.

Asexual reproduction by 4 to 8 quadriflagellated zoospores. Sexual reproduction due to biflagellate anisogametes.

Single genus examined, *Ulva*.

ULVA LACTUCA Linneaus.

Plate 1, fig. 3; Plate 6, fig. 21.

Ulva lactuca Linneaus in CHAPMAN (1956) 388-389, fig. 321b; GILBERT (1942a) 36-37, Pl. 1, fig. 8; SMITH (1944) 45, Pl. 3,

Frond membranous, flat, light to bright green, attached by an inconspicuous holdfast, irregular in outline but generally somewhat rounded; 6 to 31 cm in diameter. Margin entire, undulate, lobed or folded; membrane thicker near base. Cells polygonal in surface view, 10.8 to 25.2 μ width and 36.0 to 18.0 μ in length, 5.4 to 7.2 μ thick, adheres well to paper upon drying.

Descriptive material collection No. 100a.

Collections: Bubon I, Burgos: very abundant growth on rocky portions, tide pools, exposed every now and then with the ebb tide, 19, December 28, 1959; Bubon II, Burgos: basinlike in diameter, luxuriant on tide pools, anchored with a tiny holdfast to the rocky-sandy stratum, 21, December 29, 1959; Bubon I, Burgos: attached to rocks submerged during high tide, 55, April 28, 1960; Bubon I, Burgos: small green growth attached to rocks or shoreline, 75, August 2, 1960.

Order SIPHONALES

Plants coenocytic, branched, unbranched or aggregated to more or less elaborate shapes, free or calcified showing differentiation of rhizoidal and assimilative portions and often of stoloniferous portions as well. The most outstanding characteristic is the rare production of septa, except for a certain family,

expanding apex. Cells angular, irregularly arranged, 10.3 to 28.8 μ wide, and 18.0 to 32.4 μ long, walls not thickened.

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Valoniaceae which assumes multicellular condition through a special process called segregative division. Coenocyte wall sometimes braced by ringlike thickening which divides the cavity into separate chambers known as trabeculae. Nuclei and small chromatophores very numerous and pyrenoids absent or present.

Key to the families

1. Thallus stoloniferous, with variously shaped assimilators, with or without trabeculae Caulerpaceae
1. Thallus not stoloniferous, made up of richly branched di- or trichotomously branched threads with lateral utricles Codiaceae

Family CAULERPACEAE

Plants stoloniferous, giving branched or unbranched rhizoids below and erect branches above; the latter assuming a great variety of forms; central vacuole traversed by a system of skeletal strands called trabeculae.

Single genus examined, *Caulerpa*.

CAULERPA RACEMOSA (Forsskål) J. Agardh var. CLAVIFERA (Turn.) Weber Van Bosse.

Caulerpa racemosa (Forsskål) J. Agardh var. *clavifera* (Turn.) Weber van Bosse in DANGANAN (1955) 41, Pl. 7, figs. 28a-28b; GILBERT (1942a) 139-145, (1942) 17-18; TAYLOR (1942) 34.

Plant robust, of moderate size, stolons branched, up to 3 mm in diameter, foliar axes up to 30 mm high, at intervals of 1 to 20 mm. Rhizoids up to 28 mm in length, stout, finely branched in sandy-muddy stratum, not finely branched in sandy stratum, dividing immediately or 4 mm farther from the point of attachment to the stolon. Cylindrical axes with pyriform, alternately disposed ramelli, consisting of a short stalk, 0.5 to 1 mm in length, gradually expanding to a globose end, 2 to 3 mm in diameter.

Descriptive material collection No. 93.

Collections: Bubon I, Burgos: creeping, green growth on rocky substratum, 15, 16, December 28, 1959, green luxuriant growth on sandy-rocky substratum, rhizoids adhering to pieces of corals waist- to knee-deep at low tide growing with *Udotea* and other green algae, 93, November 18, 1960; Dirique, Pasuquin: green creeping growth among corals ankle-deep on shoreline near PC detachment, 70, August 2, 1960; Bubon I, Burgos: green creeping growth on sandy-rocky stratum with *Gelidiella acerosa* and *Caulerpa sertularioides* waist-deep during low tide,

73, August 2, 1960; Bubon II; Burgos: creeping abundant growth on sandy rocky substratum growing with other green algae 3 to 5 feet deep during low tide, 102, November 18, 1960.

Family CODIACEÆ

Plants branched, threadlike, composed of free or interwoven, continuously branching threads apparently pluricellular by constrictions. Main threads dichotomously or trichotomously branched with laterals that bind the main axis and compactly agglomerated to form a cortical layer, the swollen ends or "utricles" forming a pseudoparenchymatous surface. Main threads show constrictions especially near the points of branching where there are annular thickenings that almost meet at the centers.

Single genus examined, *Codium*.

Key to the species of *Codium*

1. Thallus segments not connected here and there by strands of rhizoidal fibers *C. papillatum*
1. Thallus segments connected here and there by strands of rhizoidal fibers 2
2. Thallus cylindrical throughout; 2 to 4 mm in diameter. *Codium* sp.
2. Thallus more or less compressed; 3 to 6 mm broad..... *C. intricatum*

CODIUM PAPILLATUM Tseng and Gilbert.

Codium papillatum Tseng and Gilbert in DAÑANAN (1955) 50, Pl. 10, fig. 47, Pl. 11, fig. 48; GILBERT (1942a) 171, SILVA (1959) 143-145, Pl. 12a.

Plant dark green, up to 10 cm high, attached to substratum by a small circular discoid holdfast; irregularly subdichotomously branched; branching divaricate; segments between dichotomies short, young apical segments much longer, whiplike, cylindrical; older ones compressed, especially at the dichotomies usually about 5 to 7 mm broad: utricles subcylindrical to obovate, with truncate apices; hair scars abundant just below the apex of utricle, causing them to adhere to one another; 255 to 420 μ wide and 750 to 1,125 μ long; gametangia elliptical to lanceolate-ovoid; 90 to 105 μ wide, 270 to 390 μ long, borne singly or in two's.

Descriptive material collection No. 13b.

Collections: Bubon I, Burgos: small, green erect growth on rocks neck-deep during low tide, 13b, December 29, 1959; Gaang, Currimaos: green erect growth attached on pieces of small rocks cast ashore after a high wind, 28, April 26, 1960; Bubon

I, Burgos, dark green erect growth attached to rocks neck-deep during low tide in association with other green algæ, 63, April 28, 1960.

It is with some hesitation that this specimen is assigned here, principally because the large size of the utricles does not conform with the measurements (120 to 270 μ broad, 640 to 870 μ long) of Gilbert (1942a) and Dañganan (1955). However, since the shapes of the utricles and gametangia and the external morphology of the plant agree so well with Gilbert's description of the Philippine specimen, it is felt that the plant should be referred to this species.

Codium sp.

Plate 2, fig. 6; Plate 7, fig. 21.

Codium sp. DAWSON (1956) 39; GILBERT (1942a) 164-172, Pl. 9-10; SILVA (1959) 103-165.

Plant decumbent, irregularly dichotomously branched, lax, often with bifid tips, intertangled, segments cylindrical, 2 to 4 mm broad, here and there attached to one another by tufts of rhizoidal filaments; utricles large, cylindrical to more usually clavate, 240 to 825 μ broad and 735 to 1,446 μ long, apices rounded or truncate; hairs present, usually several at the tip or on the zone immediately below; gametangia elliptical to oblong, attached near the middle of the utricle; 105 to 165 μ broad and 315 to 480 μ long; medullary filaments 45 to 105 μ broad, with a characteristic bulge where the constriction or thickening near the base of the utricle is located.

Descriptive material collection No. 65.

Collections: Bubon I, Burgos: anastomosing, dark green growth attached to rocks abundant on deeper parts of the sea, 13, December 28, 1959; Gaang, Currimao: soft, dark green abundant growth 6 feet below sea level, 37, 40, April 26, 1960; Bubon I, Burgos: very abundant soft, dark green growth 10 feet deep, attached to sandy-muddy substratum, 65, April 28, 1960; young, green soft, wormlike entangled growth on rocks neck deep, 91a, November 18, 1960.

The bifid tips of the segments, intertangled character of the plant caused by the presence of rhizoidal fibers connecting them with one another agree well with *Codium Geppii* as described by Gilbert(21) based on Philippine materials. However, the large utricles, 735 to 1,446 μ length and the shape of the gametangia, cylindrical to generally clavate (Plate 2, fig. 6) does not conform with *C. Geppii*, which is lanceolate, oval or fusiform.

CODIUM INTRICATUM Okamurai.

Plate 2, fig. 5; Plate 7, fig. 25.

Codium intricatum Okamurai in DAWSON (1956) 39; GILBERT (1942a) 164-169; SEGAWA (1956) 20, Pl. 2, fig. 10; YAMADA (1950) 179.

Thallus prostrate, creeping, irregularly dichotomously branched, with the branches more or less compressed especially at the dichotomies, 3 to 6 mm broad; here and there attached to one another by strands of rhizoidal fibers; utricles sub-cylindrical to clavate, 165 to 315 μ broad and 750 to 1,150 μ long with a thin wall that is only slightly thickened at the apex; gametangia fusiform, 75 to 150 μ broad and 255 to 360 μ long.

Descriptive material collection No. 13a.

Collections: Bubon I, Burgos: green creeping, dense growth on ocean floor, 6 feet deep, 13a, December 28, 1959; green' abundant growth attached to rocks neck-deep during low tide, 60, April 28, 1960; young scanty growth attached to rocks submerged under water with *Laurencia okamurai* and *Gelidiella acerosa*, 74, August 2, 1960; dark green growth in clumps underneath rock crevices waist-deep during high tide with *Anadyomene stellata*, 91, 91a, November 18, 1960; Buraan, Burgos: spongy, dark green growth on rock crevices of tide pools waist-deep during low tide, 124, November 19, 1960; Bubon II, Burgos: small growth attached to rocks neck-deep, 105, November 18, 1960.

Class PHÆOPHYCEÆ

Plants of considerable variety in form and structure. The chief distinguishing characteristic is the dominance of fucoxanthin, a brown pigment, in addition to the more usual carotinoid pigment associated with chlorophyll. Thallus corticate or eocorticate, monosiphonous to flat, mono- or polystromatic frond or a complex pseudoparenchymatous body exhibiting marked division and specialization of function.

Only genus *Hydroclathrus* represents this class belonging to order Punctariales, family Encoeliaceæ.

Order PUNCTARIALES

Plants filiform or membranous-expanded; always parenchymatous throughout and with cell division intercalary and not definitely localized in a meristem. With unilocular or plurilocular sporangia only or with both pluri- and unilocular sporangia; sporangia either remote from one another, grouped

in small sori, or completely covering surface of thallus; sometimes bearing functional gametangia and anisogametes on a very small filamentous phase.

Family ENCOELIACEÆ

Sporophytes foliose, saccate, clathrate or cylindrical; usually unbranched; thalli parenchymatous throughout and with cell division intercalary; with either unilocular or plurilocular sporangia only, or both sporangia.

Gametophyte microscopic, filamentous and with plurilocular gametangia.

HYDROCLATHRUS CLATHRATUS (Bory) Howe.

Plate 2, fig. 7; Plate 7, fig. 26.

Hydroclathrus clathratus Howe in DAWSON (1954) 403, fig. 18b; FRITSCH (1945) 110-111, fig. 39.

Thalli fleshy pulvinate, large, brownish in color, reaching up to several cm in diameter, at first hollow, coarsely clathrate, later ruptured and variously lobed and folded, perforation 1 to 29 mm in diameter. Structurally showing a layer of small medullary cells on the outer periphery and large, colorless cells on the inner side. Hairs present, unicellular, abundant on the outer surface arising from ill-defined depressions. Sporangium not seen.

Descriptive material collection No. 27.

Collections: Bubon II, Burgos: small, brownish growths attached to rocky-sandy bottom, considerably old, bigger ones floating, carried by the waves, 27, December 29, 1959; Gaang, Currimao: brownish, dirty growth attached to rocks growing with *Colpomenia sinuosa*, 32; April 26, 1960; Bubon I, Burgos: scattered in association with other algæ over considerable stretches of reef, knee-deep at lowest tide, 58, April 28, 1960.

Class RHODOPHYCEÆ

Plants branched or unbranched, monosiphonous to pseudo-parenchymatous, expanded, of a definite macroscopic form. The chief distinguishing characteristic is the predominance of phycoerythrin, a red pigment in association with phycocyanin and chlorophyll. Color ranges from red to deep purple in deep habitats. Plants have greenish tinge when growing in shallow pools exposed to a great deal of light. Food reserve is a type of starch known as "floridean starch."

Class Rhodophyceae is represented in this work by the Bangioideae and Florideae groups. There is a marked alternation of generations, the sporophytic generation bearing tetraspores and the gametophytic bearing carpogonia and spermatia either on the same or in different plants. Sexual reproduction is fertilization of the egg cell by a nonciliated sperm known as spermatium.

Key to the subclasses

1. Plants membranous, cells not evidently connected by protoplasmic strands Bangioideae
1. Plants not membranous, habit of various forms, cells conspicuously connected by protoplasmic strands Florideae

Subclass BANGIOIDEAE

Order BANGIALES

Cells forming the thallus membranous and in thickness of one or two cell-layers: obvious protoplasmic continuity never established; red, violet, or occasionally bluish-green in color; plastids stellate. Asexual reproduction is by naked monospores or fragmentation in multicellular forms; sexual reproduction by spermatia and carpogonia; monoecious or dioecious, fertilization resulting in the reproduction of carpospores.

Single genus examined, *Porphyra*.

PORPHYRA CRISPATA Kjellman.

Plate 3, figs. 8a—c; Plate 7, figs. 27a—b.

Porphyra crispata Kjellman in CHAPMAN (1941) 143; DAWSON (1954) 412, fig. 24; MACCAUGHEY (1918) 143; SEGI (1959) 251–253, Pl. 9.

Frond membranous, purplish-red to deep purple in color; expanding above into a soft gelatinous blade, 1 to 7 gregarious clusters growing from a minute adhesive disc with rhizoidal outgrowths in contact with the substrate. Blades monostromatic, obovate to linear-lanceolate or roundish with minute marginal teeth: 1.5 to 6 cm high; 1 to 3 mm broad, showing a ruffled character arising from intercalary growth. Vegetative cells angular with round corners in surface view, 7.2 to 32.4 μ in length and 5.4 to 14.4 μ in width; 3.4 to 10.8 μ thick as seen in surface view; more or less regularly arranged, chromatophores invisible. Carpospores in adjoining packets of 4 to 8 near the margins spreading over the whole frond, dark colored, intermixed with light colored vegetative cells. Monoecious. Spermatia (Fig. 8c) light colored, mixed with carpospores.

Descriptive material collection No. 11.

Collections: Bubon I, Burgos: slippery, purple-reddish growth attached to fully exposed rocks, constantly splashed

by strong waves in association with other red algæ, 11, December 11, 1959; scanty growth on rocks splash every now and then by spray of waves, intermittently exposed to sunshine in an elevated rocky portion of shore near Cape Bojeador, 67, April 28, 1960; minute purplish-pinkish with brownish tinge, abundant growth in clumps or in association with other algæ firmly attached to rocks by means of a tiny holdfast on exposed rocky elevation in the vicinity of Cape Bojeador, 89, November 18, 1960.

Subclass FLORIDEÆ

Key to the orders

1. Plants small and wiry, of tough consistency Gelidiales
1. Plants large, not wiry, not of tough consistency 2
 2. Growth fleshy, flattened, slippery Cryptonemiales
 2. Growth slender to massive, terete, cartilaginous-sturdy consistency 3
3. Main axes and branches more often massive, cartilaginous. Gigartinales
3. Main axes and branches slender, of sturdy consistency.... Ceramiales

Order GELIDIALES

Plants with slender, wiry, subsimple or redidivided branches, small to moderately large; structure multiaxial and becoming corticated. Asexual plants reproducing by tetrasporangia, the sporangia generally embedded in the cortex of localized areas or branchlets of the thallus; sexual reproduction by spermatangia and carpogonia on carpogenic branches.

Family GELIDIACEÆ

For characteristics, see order.

Single genus examined, *Gelidiella*

GELIDIELLA ACEROSA (Forsskål) Feldman Hamel.

Plate 3, fig. 9a-b; Plate 7, fig. 28.

Gelidiella acerosa Feldmann and Hamel in DAWSON (1954) 422;
TAYLOR (1942) 87, (1960) 351.

Plant 5 to 11 cm tall, tough and wiry, brownish black to pale green in color; the basal portion decumbent, attaching freely by haptera to small stony corals, bearing erect, free secondary branches which are often arcuate-recurved, sometimes attached at tips. Ultimate main axes cylindrical or somewhat flattened above, bearing sparingly alternately branched, terete, filiform, determinate branchlets, 2 to 4 mm long, radially, secundly or pinnately disposed; tetrasporic

branchlets irregularly disposed, fertile branchlets more or less swollen at the tips; sporangia progressively developed from the apex; cystocarps not seen.

Descriptive material collection No. 4.

Collections: Bubon I, Burgos: on tiny bits of rocks slightly exposed at low tide, 4, December 12, 1959, Dirique, Pasuquin: wiry, tough greenish growth attached to rocks on protected pools knee-deep, 44a, April 27, 1960; Bubon I, Burgos: dirty, wiry, light brownish-purplish growth with other algae submerged during low tide waist-deep, 78, August 2, 1960; creeping, blackish-brown small growths attached to small pieces of rocks and coral fragments occasionally splashed by big waves knee-deep growing with *Laurencia*, 95, November 18, 1960; Bubon II, Burgos: wiry growth creeping on rocks half submerged during lowest tide with *Acanthophora spicifera* and *Laurencia*, 167, November 18, 1960; Gaang, Currimao: creeping sometimes erect growth in association with *A. spicifera* on crevices of big boulders knee-deep near conference grounds, 115, November 20, 1960; Buraan, Burgos: blackish-brown, dirty, creeping growth with young *Dictyota* and *Padina* attached to small pebbles and pieces of rocks, 86, August 3, 1960; growing with *Caulerpa racemosa* ankle-deep during low tide attached to rocks, 126, November 20, 1960.

Order CRYPTONEMIALES

Plants with various shapes from filiform to fleshy-membranous; structure multiaxial or with central filament type, becoming corticated. Asexual reproduction by tetraspores formed in sporangia at the surface of thallus, or in sunken pits or conceptacles; sexual reproduction by spermatangia borne on surface cells or in the linings of conceptacles, and with carpogonia on carpogenic branches.

Family GRATELOUPIACEÆ

Plants terete, compressed or foliaceous, alternately radially or bilaterally branched; growth multiaxial; medulla of more or less anastomosed primary filaments often associated with more slender rhizoidal filaments; cortex of branched filaments, inner portion somewhat loose, outer part compact as seen in longitudinal view.

Single genus examined, *Halymenia*.

HALYMENIA DURVILLAEI BORY.

Plate 3, fig. 10; Plate 8, fig. 29.

Halymenia durvillaei Bory in COLLINS and HOWE (1916) 169-182;
TAYLOR (1960) 416-423, Pl. 51-53.

Plant bushy, firm, gelatinous, arising from a small basal disc, deep red to purplish red in color, 20 to 43 cm tall. Thallus complanate, branched from near the base into generally 4 to 6 major broad division, decreasing in width from base to apex, marginally beset with numerous subdivisions of slender, linear branchlets that give the bushy habit. Structurally showing in cross section a medulla made up of slender filaments well separated in a soft jelly; cortex of large cells within, small cells without, assimilating cells radially elongated.

Descriptive material collection No. 66.

Collections: Bubon I, Burgos: red, bushy growth attached to rocks neck-deep during low tide, 66, April 28, 1960; Dirique, Pasuquin: bright purplish-pinkish growth neck-deep during low tide attached by a small disc-like holdfast growing with *Titanophora*, *Galaxaura*, and *Liagora* species on big boulders, 110, November 19, 1960.

Order GIGARTINALES

Plants of various forms from filiform to fleshy membranous or crustose; corticated with either the multiaxial or central filament types of structures; asexual reproduction by tetraspores formed in sporangia scattered all over the plant just below the surface or in special branchlets; sexual reproduction by spermatia borne on surface cells of more or less restricted areas, and by carpogenic branches originating from the cortex.

Key to the families

1. Plant body cartilaginous, branched; branches terete, thick, abundantly papillose Solieriaceæ
1. Plant body sub-cartilaginous, bushy, branched; branches terete, slender to coarse, not abundantly papillose 2
 2. Thallus slender fine in growth, branch tip arcuate Hypneaceæ
 2. Thallus coarser in growth, branch tips not arcuate... Gracilariaceæ

Family SOLIERIACEÆ

Plants plane or bushy, subsimple or branched; in structure the medulla is clearly filamentous, the cortex obscurely so, appearing subparenchymatous with large cells within; tetrasporangia scattered at the surface, immersed, zonate; carpogenic branches of three or four cells borne similarly; cysto-

carps with a central mass of sterile tissue; carpospores discharged through a pore.

Single species examined, *Eucheuma muricatum*.

EUCHEUMA MURICATUM (Gmelin) Weber van Bosse.

Plate 4, fig. 11; Plate 8, fig. 30.

Eucheuma muricatum Weber van Bosse in DAWSON (1956) 40;
TAYLOR (1960) 457-460.

Plant large, 5 to 15 cm long or more in height; attached by a branching stout holdfast; texture cartilaginous; branching sparse, irregularly bilateral, terete throughout; young branches smooth, old ones abundantly papillose; cystocarps scattered all over the thallus, generally in papillæ, laterally projecting. Axis in cross section show a central medulla made up of compactly arranged small, thick-walled cells, a cortex composed of larger cells followed by smaller, radially elongated assimilatory cells.

Descriptive material collection No. 51.

Collection: Bubon I, Burgos: large, papillose growth on rocks in association with other algæ neck-deep during low tide, 51, April 28, 1960.

Family HYPNEACEÆ

Plants small, bushy, laterally branched, terete, branch tips often hooked. Structurally showing a persistent central filament and a cortex of pseudo-parenchymatous tissue, large cells within and small cells without. Zonate tetrasporangia localized on the surface of swollen branches. Cystocarps swollen.

Single genus examined, *Hypnea*.

HYPNEA CHAROIDES LAMOUROUX (1813).

Plate 4, fig. 12; Plate 8, fig. 31.

Hypnea charoides Lamouroux in DAWSON (1954) 434-436; TAYLOR (1960) 465-468.

Plant bushy, forming soft, tangled masses about 6 to 15 cm tall, repeatedly, alternately branched, terete, tapering to the extremities, large and small divisions intermixed: beset with long, numerous slender lateral, branchlets. Transverse section of thallus characterized by large medullary cells, rather thick-walled, 14 to 30 μ thick, becoming smaller in diameter towards the periphery of thallus; cortical cells of a single layer followed by smaller assimilating cells. All structures examined vegetative.

Descriptive material collection No. 23.

Collections: Bubon I, Burgos: small, spongy, fine growth on sandy-rocky places foot deep, 10, December 28, 1959; Bubon II, Burgos: spongy, reddish-purplish growth with small stones and brown growth on big rocks near shore, 42, April 27, 1960; Gaang, Currimao: dirty, purplish-reddish spongy growth with *Padina* near conference grounds, 68, August 1, 1960; Bubon I, Burgos: fine young, brownish-reddish growth with *L. okamurai* and *A. spicifera* attached to big rocks and small stones ankle-deep during low tide near the mouth of Buraan River, 83, August 3, 1960; luxuriant, fine, purplish-pinkish with brownish tinge attached to small pebbles foot-deep at low tide in spongy formation or in association with other algæ, 96, November 18, 1960; Bubon I, Burgos: brownish-pinkish erect or clumpy growth attached by a hardly discernible holdfast to pebbles or small bits of corals on submerged rocks knee-deep at low tide, 108, November 18, 1960; Gaang, Currimao: brownish-pinkish clumps of fine growth attached to big rocks half-exposed to sunlight, splashed occasionally by big waves, 114, November 20, 1960; Buraan, Burgos: erect, fine spongy growth with *A. spicifera* on rough surface of big boulders or on stones near mouth of river, 125, November 19, 1960.

Family GRACILARIACEÆ

Plants branched, bushy; slender to coarse; terete to strap-shaped, firm and often cartilaginous. Axes developing from apical cells forming a parenchymatous medulla and a narrow small-celled assimilative cortex; sporangia tetrapartite, scattered just below the cortex, spermatangia scattered, cut off from the surface cells. Single genus examined, *Gracilaria*.

Key to the species of *Gracilaria*

1. Thalli cylindrical, strongly constricted at base segments. *G. salicornia*
1. Thalli cylindrical, slender, not strongly constricted at base of segments 2
2. Branching nondichotomous, irregular, lax throughout. *G. verrucosa*
2. Branching bilateral, dense above, mainly arising in one plane. *G. coronopifolia*

GRACILARIA SALICORNIA (C. Agardh) Dawson. Plate 5, figs. 15a-b; Plate 8, figs. 32-b.
Gracilaria salicornia C. Agardh in DAWSON (1949) 105, (1954) 4-5.

Plant erect, 6 to 10 cm tall, dull-reddish to brownish-purple, cylindrical, subcartilaginous; thalli constricted at base of segments, 2 to 4 in number, arising from a common point of

origin, divaricate, subdichotomous, 3 to 4 mm in diameter. Transverse section with a parenchymatous medulla slightly thickened and a narrow 1 to 2 layers of small-celled cortical cells, smaller assimilating cells towards the periphery; rounded-angular in cross section. Tetrasporangia numerous, tetrapartite, scattered, immersed in the cortex, cystocarp not observed.

Descriptive material collection No. 41.

Collections: Dirique, Pasuquin: young dull, purplish-reddish growth attached to small bits of coral fragments foot deep, 41, April 27, 1960; greenish-purplish scanty growth on sandy-rocky substratum, ankle-deep during low tide, light purplish when decolorized, 72, August 2, 1960; Bubon I, Burgos: erect, robust growth with other red algae attached to big boulders splashed by waves every now and then at knee-deep, 98, November 18, 1960; Gaang, Currimao; small, healthy brownish-purplish, erect growth with *A. spicifera* at times exposed, overcast with calcareous powder, 117, November 20, 1960; Buraan, Burgos: erect crispy, luxuriant growth with *A. spicifera*, *H. charoides* and *G. acerosa* on protected portions of tide pools, 123, November 19, 1960.

GRACILARIA VERRUCOSA (Huds.) Papenfuss.

Plate 4, fig. 13; Plate 8, fig. 33.

Gracilaria verrucosa Papenfuss in DAWSON (1949) 13-14; (1934) 438-439; ISAAC (1956) 173-186; TAYLOR (1942) 107-108, (1960) 441.

Plant bushy, texture firm-fleshy; purplish to greenish-translucent; 11 to 25 cm tall, originating from a disc-like base, becoming free with age. Branches 1 to 2.5 mm in diameter; repeatedly dividing, alternately or occasionally nearly dichotomous with numerous lateral proliferations, strictly cylindrical, lax throughout, ultimate branches filiform. Cortex made up of 2 to 3 layers of small cells, medulla of very large thick-walled cells in the middle of the thallus, 225 to 420 μ in diameter.

Descriptive material collection No. 28.

Collections: Bubon I, Burgos: abundant, healthy growth on big tide pools partially exposed during low tide entangled with *Cutleria* species, 18, December 28, 1959; Dirique, Pasuquin: young, greenish-purplish growth attached to sandy-rocky portions of shore, 44, April 27, 1960; Bubon I, Burgos: abundant, healthy growth knee-deep during low tide attached

to small pebbles, 99, November 18, 1960; Bobon II, Burgos: abundant, brownish-greenish growth with sea-grasses knee-deep during low tide, 103, November 18, 1960.

GRACILARIA CORONOPIFOLIA J. Agardh.

Plate 5, fig. 14; Plate 8, fig. 31.

Gracilaria coronopifolia J. Agardh in ABBOTT (1947) 205-206; DAWSON (1949) 22-24; MACCAUGHEY (1918) 146.

Plant erect, cylindrical, one to several stipes arising out of a small, discoid holdfast; branching frequent, rather dense above, irregularly alternate but mainly arising in one plane. Thallus in transverse section with a medulla of thin-walled cells largest in the center, surrounded by 1 to 2 cortical layers of cells sharply distinct from the large, rotund, thin-walled medullary cells; tetraspores scattered over the surface of almost the entire thallus, embedded in the cortex immediately adjacent to the outermost smaller medullary cells surrounded by antichinal rows of modified cortical cells.

Similarities in cell structure in the transverse sections of thallus of *G. coronopifolia* and *G. verrucosa* were observed though they differ mainly in the habit of branching. However, since the reproductive structures were not observed where differences are expected to be found, more studies are recommended for this purpose.

Descriptive material collection No. 44.

Collecetions: Dirique, Pasuquin: small brownish-greenish growth attached to small bits of corals knee-deep 44c, April 17, 1960; Buraan, Burgos: brownish-reddish growth on rock crevices in association with *hypnea charoides* near the mouth of Buraan Rivar, 85, August 3, 1960; Gaang, Currimao; small, abundant growth underneath crevices of tide pools, attached to small pebbles in the vicinity of conference grounds, 118, November 20, 1960.

Order CERAMIALES

Plants generally slender, filamentous and branched, structure of the central filament type developing from an apical cell. Asexual reproduction by tetraspores formed in sporangia external or more or less covered by the cortex in ordinary branches or grouped in special branchlets or stichidia; sexual reproduction by spermatangia borne on axial filaments and carpogonia on carpogenic branches borne together with sterile cells.

Family RHODOMELACEÆ

For characteristics, see order.

Two genera were examined belonging to family Rhodomelaceæ.

Key to the genera of Rhodomelaceæ

1. Axes without short spinelike branchlets, with small pits at apices. *Laurencia*
1. Axes with short spinelike branchlets, small pits at apices absent *Acanthophora*

Key to the species of *Laurencia*

1. Surface cells elongated radially in cross section of branches, covered with wartlike branchlets *L. papillosa*
1. Surface cells not elongated radially in cross section of branches, wartlike branchlets absent *L. okamurai*

LAURENCIA PAPILLOSA (Forsskål) Greville. Plate 5, fig. 16; Plate 9, fig. 35 a-b.
Laurencia papillosa Greville in DAWSON (1954) 456-457; TAYLOR (1942) 135, (1960) 623-624, Pl. 74, fig. 21; TSENG (1943) 185-207; YAMADA (1931) 190-191.

Plant erect, purplish-green, subcartilaginous, up to 9 cm long, cylindrical, attached to substratum by rhizoidal holdfast; irregularly branch, 1 to 2 mm in diameter, naked or nearly so below. Tip and secondary divisions sparingly to very densely covered with short, clavate, truncate branchlets. Cystocarps and antheridia unknown. Surface cells as seen in cross section of frond strongly elongated radially and arranged like palisade cells; corticating cells twice as long, as broad or more; cell walls thick; lenticular thickening on medullary cells absent.

Descriptive material collection No. 104.

Collections: Bubon I, Burgos: erect, warty, dull purplish-green, abundant growth on rocks on the intertidal zone exposed to the waves, 6, 7, December 28, 1950; Bubon II, Burgos: erect, purple-green cartilaginous growth attached to rock chips, waist-deep during low tide, 47, April 28, 1960; warty, blackish-brown with purple tinge, very abundant growth attached to rocks waist-deep during low tide, 104, November 18, 1960.

LAURENCIA OKAMURAI Yamada.

Plate 5, fig. 17; Plate 9, fig. 36.

Laurencia okamurai Yamada in SEGAWA (1956) 116, Pl. 29, figs. 560-561; TSENG (1943) 185-207; YAMADA (1931) 206-207, Pl. 7, fig. J. K.

Plant erect, purplish-blue, cartilaginous, 10 cm long or more, cylindrical, 1 to 2 cm thick at the base. Main axis per current with paniculate outline; branching alternate, opposite to subverticillate, terminal branchlets cylindrical or clavate with truncate apices; tetrasporangia present on the summit; branchlets of about the same shape as sterile ones; cystocarps and antheridia not seen. Surface cells in cross section of branchlets not elongated radially, squarish, with rounded outer radial wall. Lenticular thickenings abundant in the walls of the medullary cells. (Fig. 17.)

Descriptive material collection No. 8.

Collections: Bubon I, Burgos: purplish, erect, spreading growth in knee-deep water on coral chips, 8, December 28, 1959; purplish-bluish erect growth on small rocks waist-deep, where current is always agitated by waves, 90, November 18, 1960.

ACANTHOPHORA SPICIFERA (Vahl.) Boergesen. Plate 5, fig. 18; Plate 9, figs. 37 a-h.

Acanthophora spicifera Boergesen in DAWSON (1954) 456-457, (1956) 62; FRITSCH (1954) 556-558; TAYLOR (1960) 619-621.

Plant erect, dull grayish-purple, attached to the substratum by an irregularly lobed disc; sparingly branched to bushy, alternately branched, terete branches of indefinite growth, determinate growth beset with short, spirally placed, spinous branchlets, these absent from the indeterminate shoots. Diameter of main axes 2 mm on the average; composed of parenchymatous central cells surrounded by smaller thin-walled 1 to 2 layers of corticating cells followed by the assimilating surface cells.

Descriptive material collections No. 5.

Collections; Bubon I, Burgos: small brownish-reddish spinous growth at low tide, knee-deep, 5, December 28, 1959; Bubon II; Burgos: bushy, brownish growth, 22, December 29, 1959; Gaang; Currimao: brownish-black, erect, abundant growth entangled with *Hypnea* and other red algae attached to rocks, 99, November 18, 1960; Gaang, Currimao; brownish-black small robust growth with *Gelidiella acerosa* and *Gracilaria verrucosa* attached to big boulders of rocks waist-deep at low tide, 116, November 20, 1960; Buraan, Burgos: luxuriant brownish-black growth with *Gracilaria salicornia*, *H. charoides*, and *G. acerosa* near mouth of Buraan River, 112, November 19, 1960.

DISCUSSION OF RESULTS AND RECOMMENDATION

Majority of the seaweeds under consideration belong to the red algæ group, a few belong to the green algæ, and one to the brown algæ. A characteristic of the red algæ giving them economic value is the development of complex colloidal carbohydrates in their cell wall. Chemically, they are generally galactans. They are usually phycocolloids which readily form a colloidal solution when heated and a gel when cooled [Tressler and Lemmon (1957)].

Anatomical examination of cells in transverse section of the thallus, with special reference to the Rhodophyceæ, indicates a general tendency to be thick-walled. Agar in varying amounts is a constituent of cell walls of many red algæ corresponding physiologically to the cellulose in higher plants. However, not all of the plants belonging to the Rhodophyceæ yield agar, a phenomenon which has not been explained [Cantoria (1957)]. It makes the cartilaginous, fleshy consistency of the species much relished in salads.

Of the 19 species studied, *Gracilaria*, *Hypnea*, *Gelidiella*, *Eucheuma*, *Acanthophora* and *Laurencia* are agar-yielding genera. Studies of Philippine species for agar by Cantoria (1951) showed that *Hypnea musciformis*, *Gracilaria lichenoides*, and *G. canaliculata* are excellent sources.

One can see in Table 2 that the majority of the edible seaweeds of Ilocos Norte are in abundance from November and this reaches its peak during the summer months. *Porphyra crispata*, *Gracilaria verrucosa*, *Caulerpa racemosa* var. *clavifera*, three species of *Codium*, *Acanthophora spicifera*, and two species of *Laurencia* grow in commercial quantities from November to April 1. The last three species belong to the *culot* group, which are sold in the market in fresh or dry forms any time of the year. *Ulva lactuca*, *Gelidiella acerosa*, and *Halymenia durvillaei* are, likewise, abundant, but are not as popular as the others when these are in season. Only *H. clavoides* and *C. racemosa* var. *clavifera* are available from August to October, when the others are out of season. It is evident that people along the coast of this province are busy with "sea farming" during the dry months from November to April.

Seaweeds in Ilocos Norte are mainly used for food, eaten raw or mixed with other viands. *Enteromorpha compressa*

(Plate 1, fig. 2 and Plate 6, fig. 20) and *E. plumosa* (Plate 1, figs. 1a-c and Plate 6, fig. 19), both locally known as *lumot*, are eaten raw in the form of salad mixed with sliced tomatoes, onion and a dash of salt. Species of *Codium*, *Caulerpa*, *Hydroclathrus*, *Halymenia*, *Gracilaria* and *Hypnea*, in their decreasing order of demand, are sold always fresh during their season.

Porphyra or *gamet* (Plate 7, figs. 27a-b), sold in dried form, is the most-prized seaweed and considered a delicacy among the Ilocanos. It is similar to the *amanori* or laver of Japan. The fresh alga is measured with a *ganta*, the amount of one *ganta* is evenly spread in a rectangular *sawali* woven together for sun drying. The size of the *sawali* determines the size of the resulting product after drying (Plate 7, fig. 27a). The prices of *gamet* depends upon the color and gloss of the mat. That which has a purplish-black silky appearance belongs to the first class and commands a higher price than the dull, brownish ones. Microscopic examination of the first class *gamet* reveals that cystocarps with glistening carpospores occupy the whole frond, whereas the thallus of the second class, which is much lighter in color (Plate 7, fig. 28), is composed of vegetative cells.

Acanthophora spicifera (Plate 5, fig. 18 and Plate 9, figs. 37a-b) form the greater bulk of a dried assortment of seaweeds locally known as *culot*. It is a general term given to the dried conglomeration of species of *A. spicifera*, *Gelidiella acerosa* (Plate 7, fig. 28), *Laurencia papillosa* (Plate 9, figs. 35a-b) and *Laurencia okamurai* (Plate 9, fig. 36) with some *Hypnea charoides* (Plate 8, fig. 31). The last named species is more commonly sold singly in fresh condition and known in the Ilocano dialect as "culot ti pusa." The sun-dried forms of these species are stored in a dry place for future consumption or for sale during the rainy season. *Culot*, when composed of *A. spicifera* alone, commands a higher price than when in association with other algæ of this group owing to its fleshy and soft consistency. Fresh and dried forms are served as salad. Dried *culot* is reconstituted to nearly fresh condition by blanching in boiling water for 2 minutes, rendered free from foreign materials and mixed with sliced tomatoes, onions, a little vinegar, and salt. It can also be mixed with vegetables for viand. Table 4 shows the different food preparations of the marine edible seaweeds in Ilocos Norte.

TABLE 4.—Food preparations of marine edible seaweeds in Ilocos Norte.

Scientific names	Common names	Methods of preparation
1. <i>Enteromorpha plumosa</i> Kützting	Lumot	Eaten always in raw state in the form of salad mixed with sliced tomatoes, onions and a dash of salt after a thorough washing in fresh water.
2. <i>Enteromorpha compressa</i> (Linn.) Greville	do	
3. <i>Ulva lactuca</i> Linn.	Gamgamet	Eaten in the form of salad after thorough washing in fresh water prepared as above; could be cooked with vegetables for viand.
4. <i>Enteromorpha racemosa</i> (Forsskål) J. Agardh var. <i>clavifera</i> (Turn.) Weber van Bosse.	Ararucip	Eaten always raw in fresh condition in the form of salad with sliced tomatoes and a dash of salt.
5. <i>Codium papillatum</i> Tseng and Gilbert.	Pocpoco	Eaten always in fresh condition in the form of salad garnished with sliced tomatoes and onions with a dash of salt.
6. <i>Codium intricatum</i> Okamura.	do	
7. <i>Codium</i> sp.	do	
8. <i>Hydroclathrus clathratus</i> (Bory) Howe	Balbalalang	Eaten always raw in the form of salad prepared as above after blanching in boiling water for 2 minutes and rendered free from small crabs that breed in the thallus.
9. <i>Porphyra crispata</i> Kjellman	Gamet	Eaten raw and in dried form in the form of salad prepared as above and in the form of soup dried sheets of <i>Porphyra</i> are similarly made into soup, omelets or broiled over live charcoal and mixed with sliced tomatoes, onions and sometimes with sliced cucumber and radish plus a little vinegar in proportions to suit one's taste.
10. <i>Gelidiella acerosa</i> (Forsskål) Feldmann et Hamel.	Culot	Eaten fresh or in dried form; fresh ones are made into salad prepared as above; dried ones used for future consumption are reconstituted to nearly fresh condition by blanching in boiling water for 2 minutes and mixed with the same garnishings as above; could be mixed with vegetables for viand.
11. <i>Laurencia papillosa</i> (Forsskål) Greville	do	
12. <i>Laurencia okamurai</i> Yamada	do	
13. <i>Acanthophora spicifera</i> (Vahl.) Boergesen.	do	
14. <i>Halymenia durvillae</i> Bory	Gayong-gayong	Always eaten in fresh state and prepared into salad for viand.
15. <i>Eucheuma muricatum</i> (Gmelin) Weber van Bosse.	Canot-canot	Always eaten in fresh state in the form of salad and can be added with vegetables for viand.
16. <i>Hypnea charoides</i> Lamouroux	Culot ti pusa	Eaten in raw or dried form as salad with similar garnishings as above; dried ones are similarly reconstituted to nearly fresh condition and prepared into salad.
17. <i>Gracilaria salicornia</i> C. Ag.	Cacaoayan	Eaten always in raw state in the form of salad prepared as above or added and cooked with vegetables for viand. Crude agar is extracted from these 3 species with <i>Eucheuma muricatum</i> by boiling the bleached thalli for a few hours till the gelose is extracted. The digested portion is separated from the fibrous residue by straining while hot through sinamay cloth stretched over a large vat where the solution filters. Sugar is added and food coloring; when cooled it is cut to small blocks and served with ice cream.
18. <i>Gracilaria verrucosa</i> (Huds.) Papenfuss	do	
19. <i>Gracilaria coronopifolia</i> J. Ag.	do	

TABLE 5.—Comparative study of the food values of some algæ and

Algæ	Moisture	Ash		Protein	
		fresh	dry	fresh	dry
ALGÆ		Per cent	Per cent	Per cent	Per cent
Gulaman dagat (<i>Gracilaria</i> sp.)	6.92	15.31	16.48	11.98	12.89
Hypnea (<i>Hypnea</i> sp.)	9.44	22.03	24.37	8.60	9.49
Gamet (<i>Porphyra</i> sp.)	35.71	15.70	24.42	12.56	19.54
Pokpoklo (<i>Codium</i> sp.)	93.59	2.98	45.89	0.15	2.34
Bitukang manok (<i>Euteromorpha intestinalis</i>)	81.35	6.02	32.27	3.66	19.61
Lumut jusi (<i>Chaetomorpha linum</i>)	86.56	2.62	19.50	3.72	27.66
Cladophora (<i>Cladophora</i> sp.)	57.24	9.90	23.16	1.96	5.16
VEGETABLES					
Kangkong leaves (<i>Ipomoea aquatica</i>)	84.21	1.149	9.44	3.62	22.93
Talinum leaves (<i>Talinum triangulare</i>)	91.75	1.49	18.06	3.61	28.93
Kamote leaves (<i>Ipomoea batatas</i>)	81.52	1.94	15.54	3.66	19.61

Majority of the edible seaweeds of this province are served in the form of salads. *Hydroclathrus clathratus* (Plate 7, fig. 26), known locally as balbalulang, is similarly prepared after carefully washing in fresh water. People accustomed to eat this particular species say that it is dangerous to eat during the *curet* season. *Curet* are crabs, the size of a pinhead, that breed in the thallus of the *Hydroclathrus*. Eating balbalulang with *curet* results in death in some cases. This species, together with *Sargassum* and *Turbinaria*, is reported by Sulit, et al. (1952) to be a possible source of alginic acid.

Salads are also made with *Ulva lactuca* (Plate 6, fig. 21), locally called *gangamet*, the three species of *Codium* (Plate 6, fig. 23, and Plate 7, figs. 24–25), collectively known as *pokpoklo*, *Caulerpa racemosa* var. *clavifera* (*ararusip*) in Plate 6, fig. 22, *Halymenia* (*gayong-gayong*) in Plate 8, fig. 29 and *H. charoides* (Plate 8, fig. 31), the three species of *Gracilaria* (Plate 8, figs. 32–34) and *Eucheuma muricatum* (Plate 8, fig. 30). *Gracilaria salicornia* (Plate 8, figs. 32a–b) is known as *canot-canot* in Currimao and Pasuquin. It is eaten in Currimao, but not in Pasuquin and the rest of the place visited. *Gracilaria verrucosa* (Plate 8, fig. 33) is known by different common names: *cuocaoyan* in Burgos and *maracaoyan* in Currimao (Table 3). *Gangamet* (*U. lactuca*) literally translated into English means pseudo-*Porphyra*. Its habit is similar to *Porphyra*, only it is green while *gamet* is red. *Ulva* (Plate 6, fig. 21) is much bigger than *Porphyra* (Plate 7, fig. 27a). Table 5 shows a comparative study of the values of some algæ and vegetable plants [after Sulit, et al. 1952].

vegetables [After Sulit, et al. (1952)].

Fat		Calcium		Phosphorous		Potassium		Magnesium	
fresh	dry	fresh	dry	fresh	dry	fresh	dry	fresh	dry
Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
0.92	0.99	2.325	2.498	0.531	1.572	0.266	0.286	0.588	0.632
0.65	0.91	15.818	16.711	0.127	0.140	3.568	3.939	0.601	0.663
0.79	1.32	2.250	3.499	2.009	3.124	0.977	1.519	0.34	0.048
0.08	1.21	0.038	0.594	0.003	0.043	0.242	3.769	0.007	0.112
0.48	2.57	0.202	1.080	0.179	0.961	0.445	2.384	0.314	1.684
0.32	1.71	0.083	0.621	0.119	0.889	0.371	2.761	0.168	1.249
0.64	1.96	0.422	0.988	0.403	0.943	1.520	3.566	0.785	1.838
0.32	2.03	0.056	0.357	0.099	1.626	0.374	2.367	0.056	0.358
0.27	3.29	0.057	0.692	0.052	0.634	0.426	5.157	0.106	1.288
0.22	1.77	0.096	0.792	0.108	0.867	0.615	0.928	4.091	0.731

On the whole, red algæ grow at the greatest depth while the brown occur mostly in places exposed at every tide turn or only partially submerged at the lowest tide. The green algæ occur high up where they are exposed with the ebb and flow of the tides. Thus, we have the beautiful red alga, *Halymenia durvillaei* (Plate 8, fig. 29), growing on portions of the sea which are neck-deep during low tide. The brilliant green *Ulva lactuca* are found on shallow rock pools of the upper littoral zone. Most of the algæ collected for this study are littoral zone inhabitants. The littoral zone is the home of a considerable number of annuals, like the species of *Laurencia*, *Acanthophora*, *Hypnea* and *Gelidiella*, all belonging to the *culot* group. The characteristic richness and abundance of algal growth in this zone reach a maximum during summer, from March to April. The variety of the three species of *Codium* and one of *Caulerpa* in this zone is noticeable. On the other hand the sublittoral growth are very abundant, big and healthy. From the latter comes the greater bulk of the commercial *polopoko* and *ararusip*.

RECOMMENDATIONS

1. Nineteen edible species of marine algæ are largely eaten as food in Ilocos Norte. Since other if not similar species are also being eaten in other parts of the country, similar studies should be made wherever seaweeds form an important part in the diet of the people.

2. The period of gathering is generally seasonal and exploitation of algal resources appears to be continuously practiced by the inhabitants of adjacent communities. This results to a decline in supply, which should be remedied at once.

3. Systematic seaweed culture and utilization are necessary. There is a need to survey richer grounds where algae of economic importance occur and their seasonal abundance is known. This is tapping one of the probably richest natural resources of the country.

4. With the known extensive shorelines, the harvesting of several species, especially the genus *Porphyra*, could be easily initiated by culture. The spores may be allowed to settle on rough surfaces of stone boulders or coarse fish nets, transferred to culture grounds, and allowed to grow. Harvesting may be done after a period of about 3 months.

5. Better methods of harvesting, preparing and storing the seaweeds, should be studied and introduced since the present practice does not keep the products long. Unlike *Porphyra*, *Gracilaria*, *Laurencia*, *Gelidiella* and *Acanthophora*, the others, such as *Codium*, *Caulerpa*, *Hydroclathrus* and *Hypnea*, are sold and eaten immediately after collecting from the sea. People will always prefer to eat highly preserved quality of seaweeds.

6. On the basis of the knowledge obtained from the abundance of edible seaweeds in Ilocos Norte, a seaweed industry should be considered for establishment locally. Just as seaweed industries in other countries have contributed amply to their economy, any seaweed industry in the Philippines, when properly managed, can be a major source of income.

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GLOSSARY OF COMMON NAMES¹

1. *Acanthophora spicifera*—culot
2. *Caulerpa racemosa* var. *clavifera*—ararusip; ararucip
3. *Codium intricatum*—pocpoclo; pokpoklo; pupu-lo
4. *Codium papillatum*—pocpoclo; pokpoklo; pupu-lo
5. *Codium* sp.—pocpoclo; pokpoklo; pupu-lo
6. *Enteromorpha compressa*—lumot; guraman
7. *Enteromorpha plumosa*—lumot
8. *Eucheuma muricatum*—canot-canot
9. *Gelidiella acerosa*—culot; kulot
10. *Gracilaria verrucosa*—caocaoyan; maracaoyan; garararao; gurguraman; guraman
11. *Gracilaria coronopifolia*—caocaoyan
12. *Gracilaria salicornia*—canot-canot
13. *Halymenia durvillaei*—gayong-gayong
14. *Hydroclathrus clathratus*—balbalulang
15. *Hypnea charoides*—culot ti pusa; culot
16. *Laurencia okamurai*—culot
17. *Laurencia papillosa*—culot; alalocon
18. *Porphyra crispata*—gamet
19. *Ulva lactuca*—gangamet; maragamet.

¹ Common names of the 19 species included in this paper. The common name first cited after each species is the one adopted in this work; the rest were taken from local references.

ILLUSTRATIONS

PLATE 1

- FIG. 1a-c. *Enteromorpha plumosa* Kützting
 2. *Enteromorpha compressa* (Linn.) Greville
 3. *Ulva lactuca* Linn.

PLATE 2

- FIG. 4. *Codium papillatum* Tseng and Gilbert
 5. *Codium intricatum* Okamura
 6. *Codium* sp.
 7. *Hydroclathrus clathratus* (Bory) Howe

PLATE 3

- FIG. 8a-c. *Porphyra crispata* Kjellman
 9a-b. *Gelidicella accrosa* (Forsskål) Feldmann and Hamel
 10. *Haplomenia durvillaei* Bory.

PLATE 4

11. *Eucheuma muricatum* (Gmelin) Weber van Bosse
 12. *Hypnea charoides* Lamouroux
 13. *Gracilaria verrucosa* (Huds.) Papenfuss

PLATE 5

- FIG. 14. *Gracilaria coronopifolia* J. Agardh
 15a-b. *Gracilaria salicornia* C. Agardh
 16. *Laurencia papillosa* (Forsskål) Greville
 17. *Laurencia okamurai* Yamada.
 18. *Acanthophora spicifera* (Vahl.) Boergesen

PLATE 6

- FIG. 19. *Enteromorpha plumosa* Kützting
 20. *Enteromorpha compressa* (Linn.) Greville
 21. *Ulva lactuca* Linn.
 22. *Caulerpa racemosa* (Forsskål) J. Ag. var. *clarifera* (Turn.)
 Weber Van Bosse
 23a-b. *Codium papillatum* Tseng and Gilbert

PLATE 7

- FIG. 24. *Codium* sp.
 25. *Codium intricatum* Okamura
 26. *Hydroclathrus clathratus* (Bory) Howe
 27a-b. *Porphyra crispata* Kjellman
 28. *Gelidella accrosa* (Forsskål) Feldman and Hamel

PLATE 8

- FIG. 29. *Halymenia durvillae* Bory.
30. *Eucheuma muricatum* (Gmelin) Weber van Bosse
31. *Hypnea chroides* Lamouroux
32a-b. *Gracilaria salicornia* C. Agardh
33. *Gracilaria verrucosa* (Huds.) Papenfuss

PLATE 9

- FIG. 34. *Gracilaria coronopifolia* J. Agardh
35a-b. *Laurencia papillosa* (Forsskål) Greville
36. *Laurencia okamurai* Yamada
37a-b. *Acanthophora spicifera* (Vahl) Boergesen

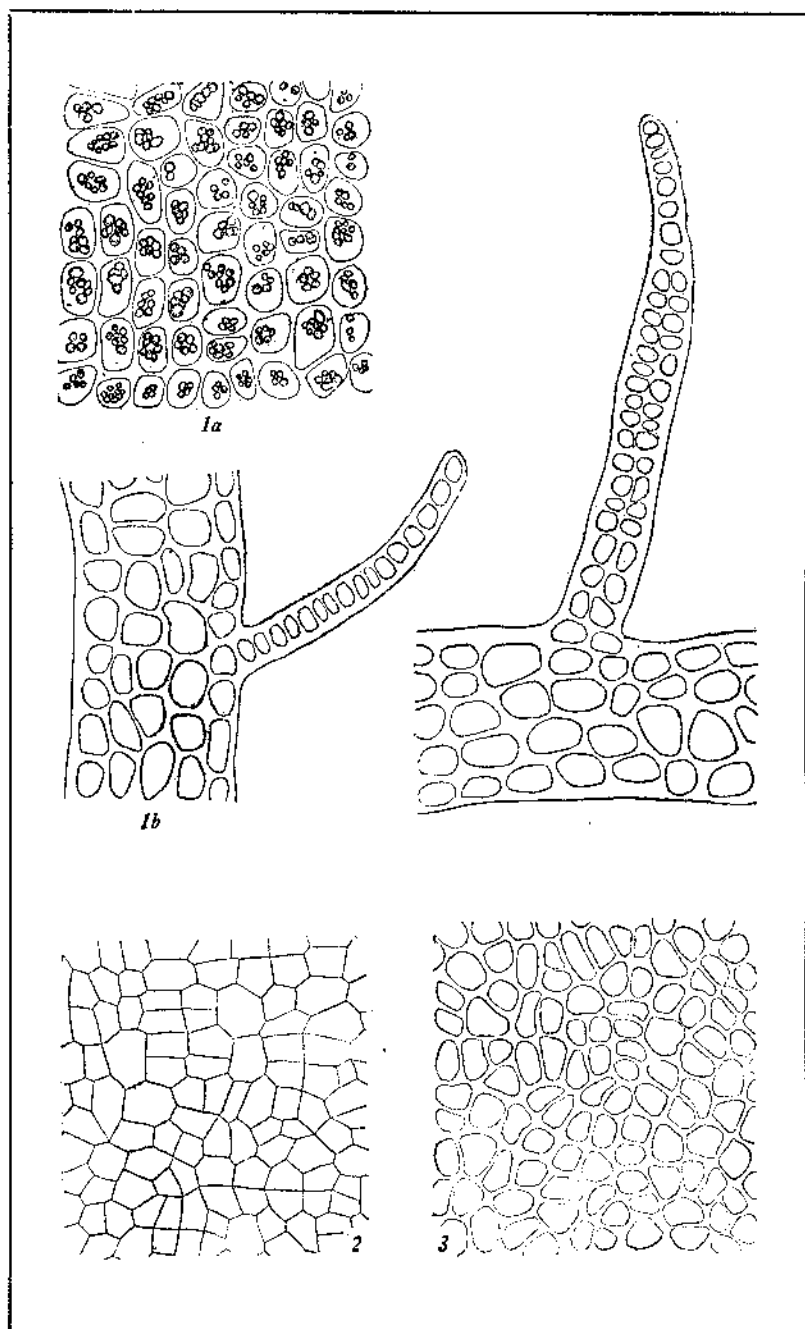


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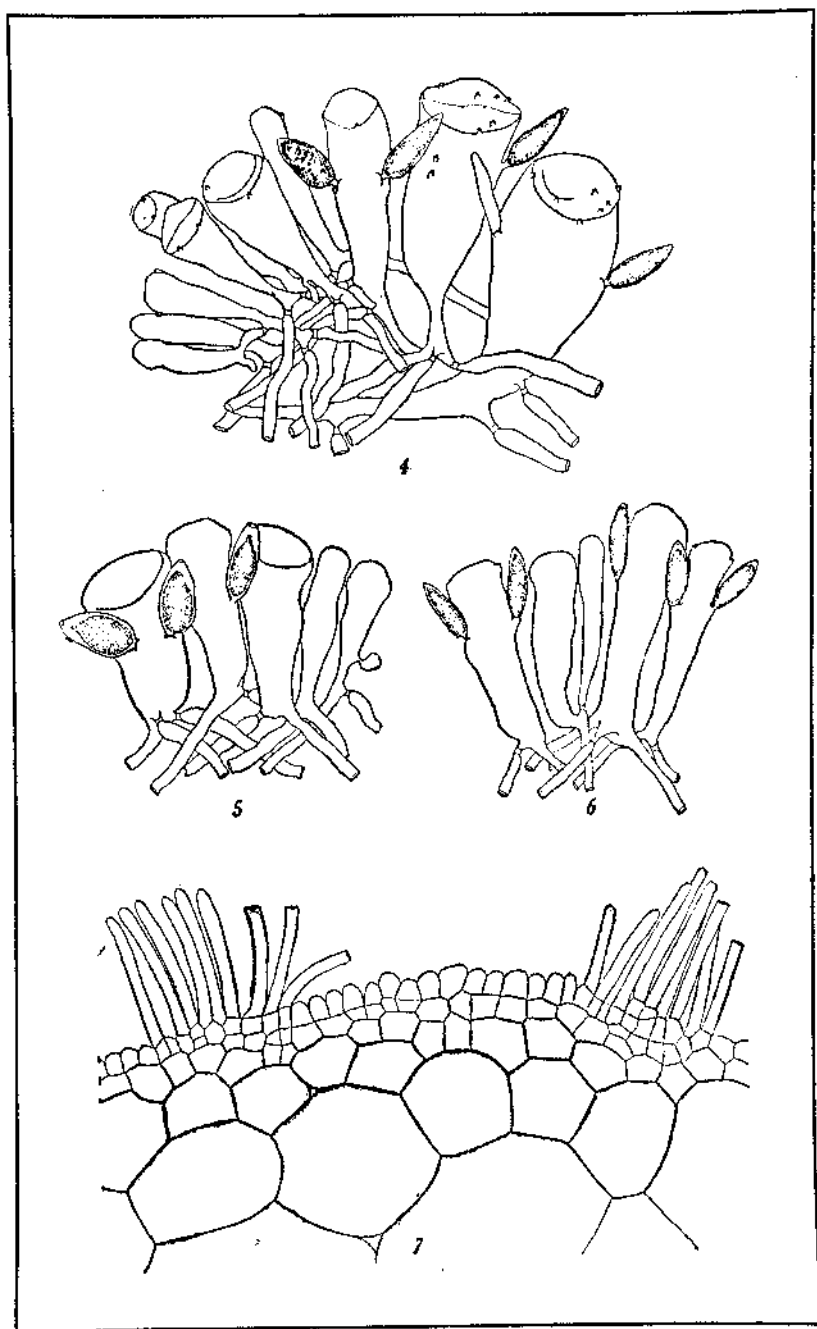


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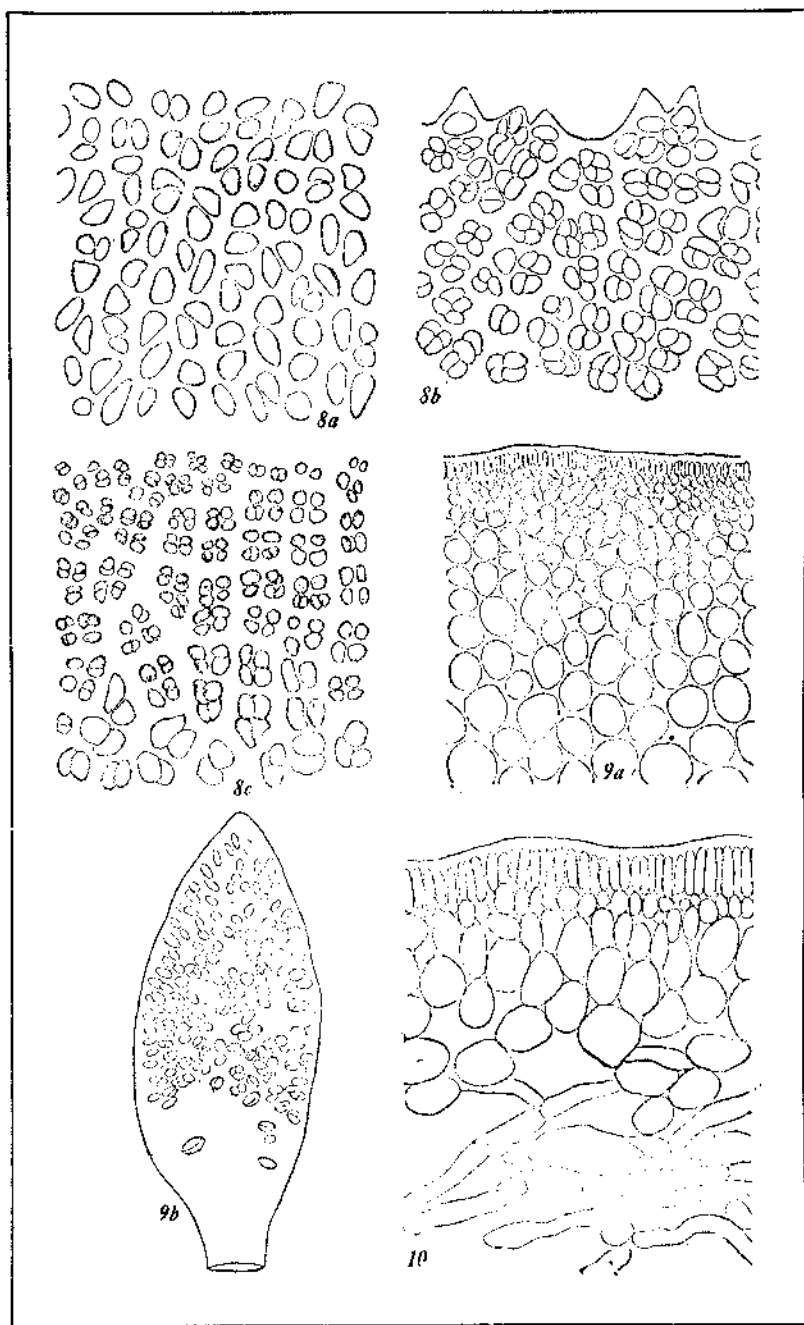


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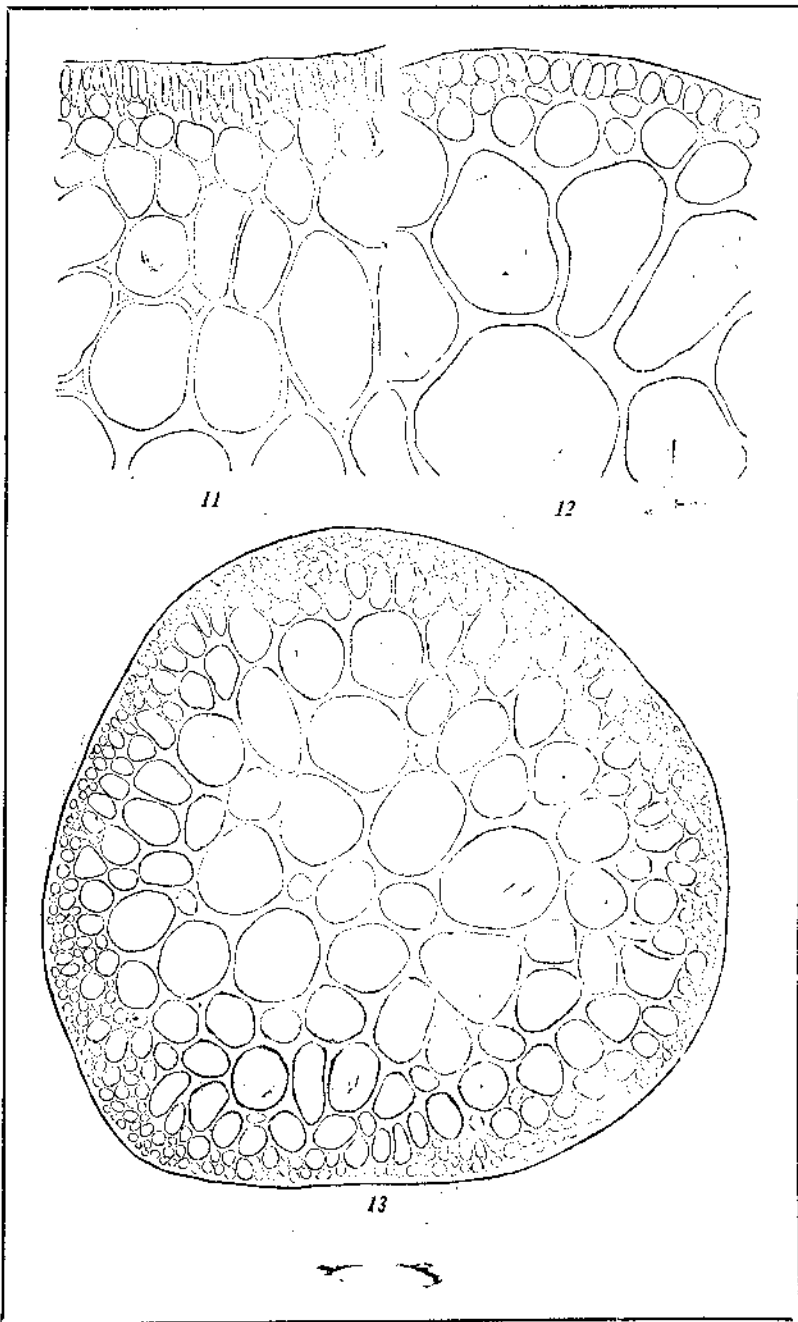


PLATE 4.

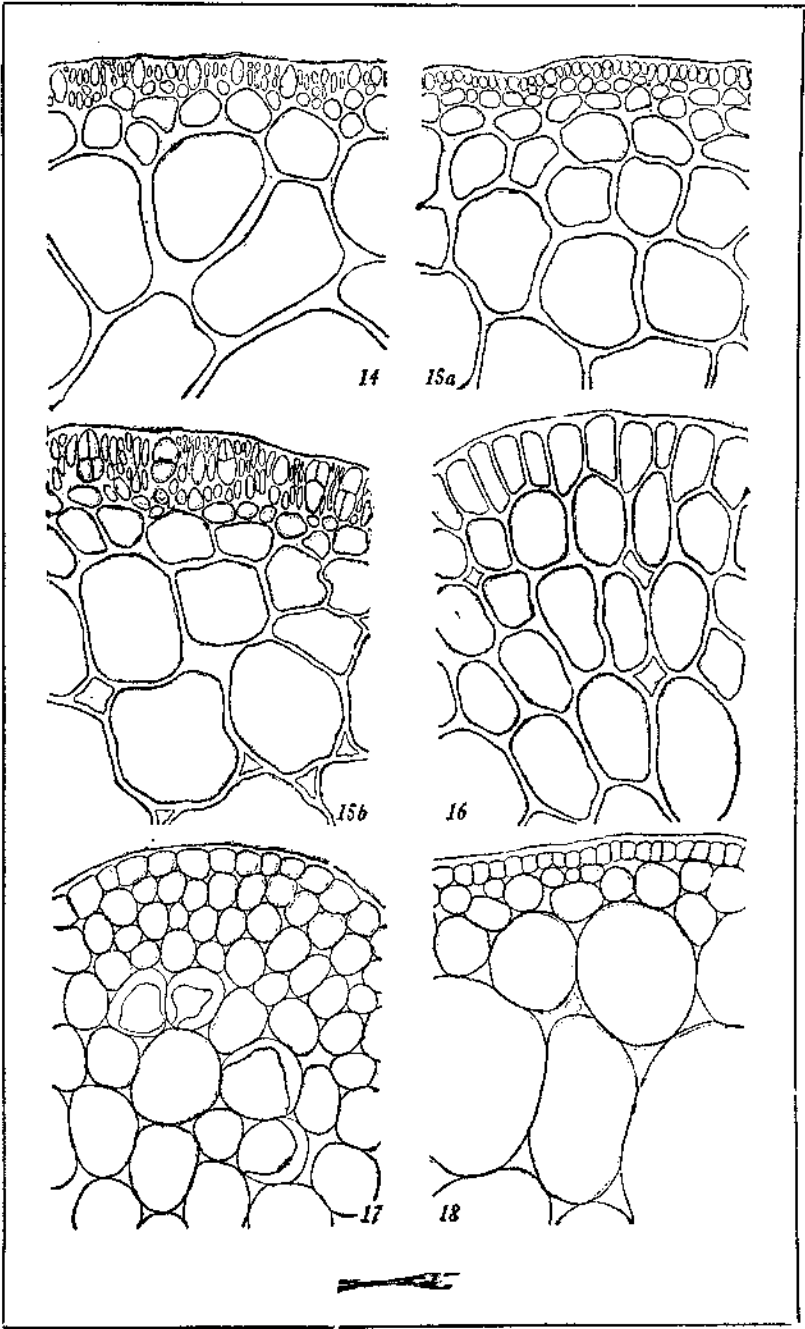
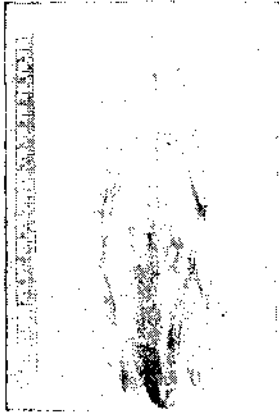


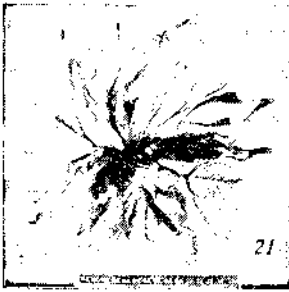
PLATE 5.



19



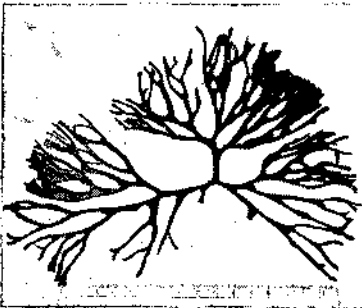
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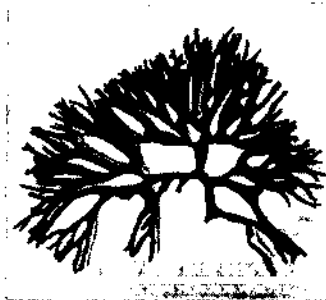
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22



23a



23b

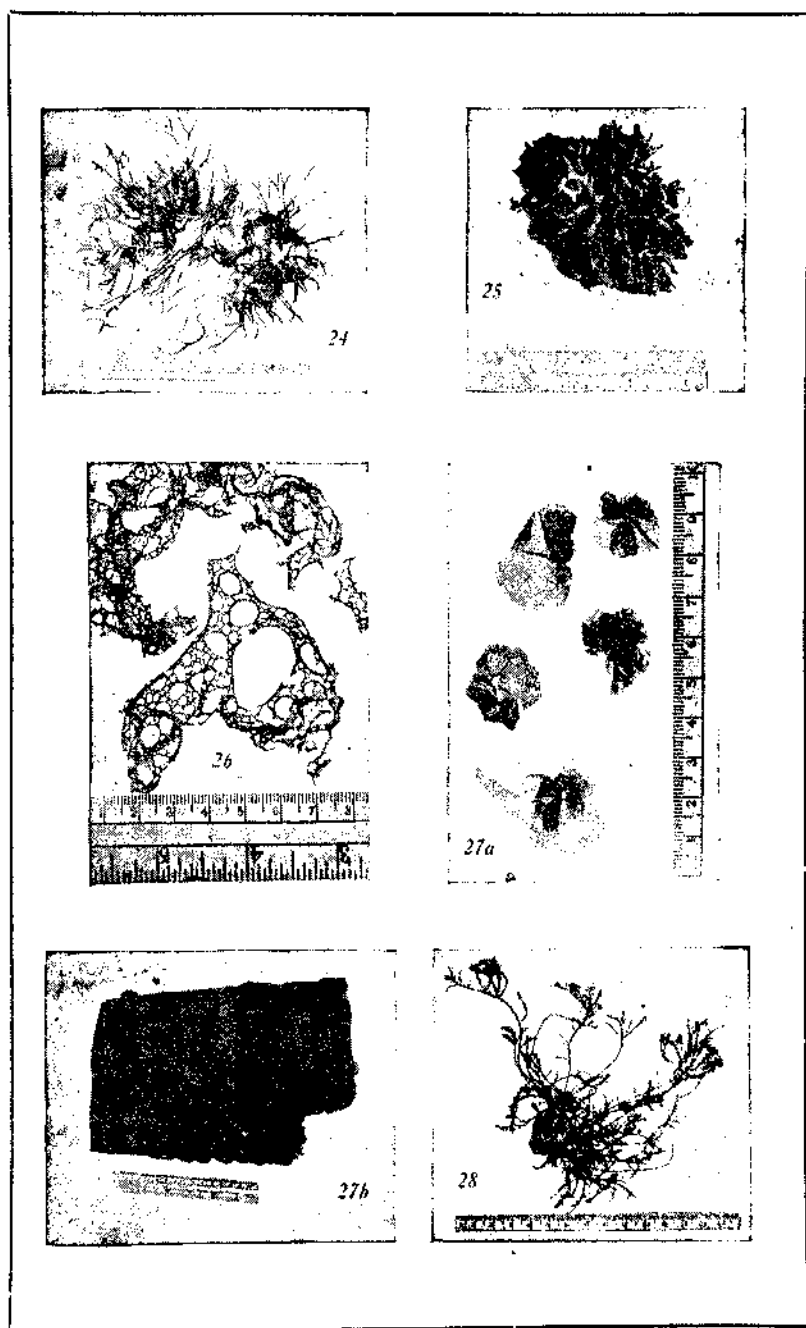


PLATE 7.

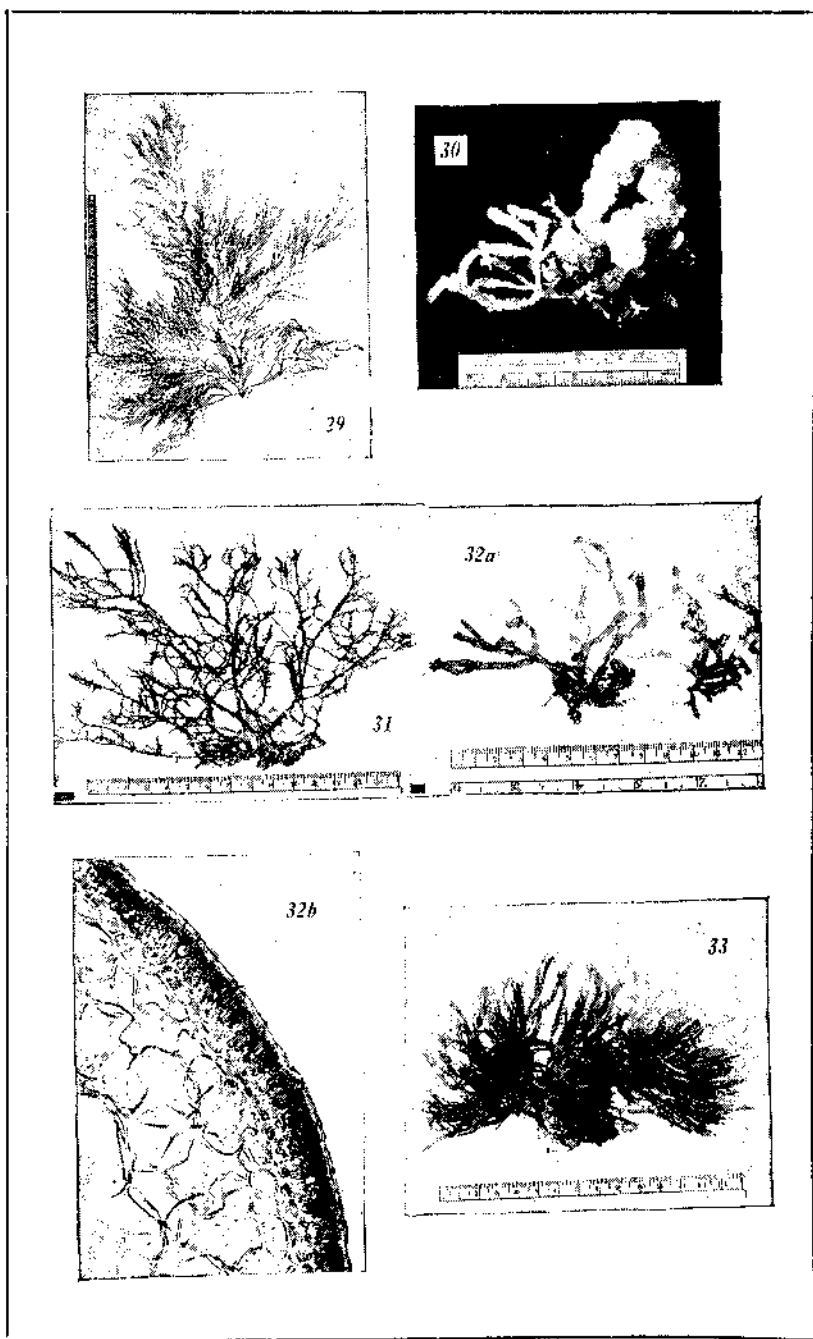


PLATE 8.

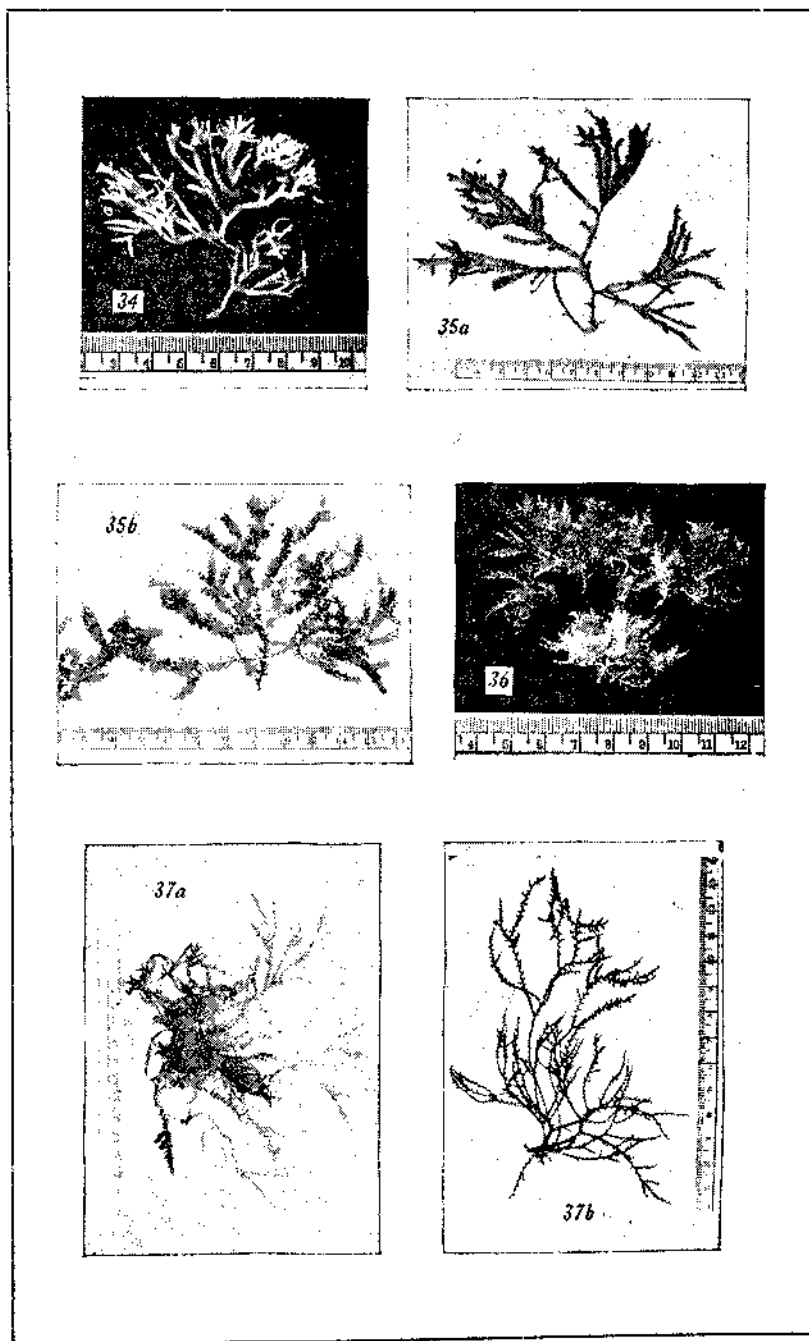


PLATE 9.

CONTRIBUTIONS TO A REVIEW OF PHILIPPINE SNAKES, III

THE GENERA MATICORA AND CALLIOPHIS

By ALAN E. LEVITON

California Academy of Sciences, San Francisco 18, California

ONE TEXT FIGURE

Two genera of small coral snakes (Family Elapidæ) are found in the Philippines. The genus *Maticora* is known from the Palawan Archipelago, Mindanao, Samar, and Jolo islands; *Calliophis* is known from Luzon, Polillo, Negros, Panay, and Cebu (Fig. 1). The two genera have not been taken together in the same island though Casto de Elera and Fischer reported *Calliophis* to have been taken in Mindanao, and Griffin listed *Maticora* from Manila, Luzon; these records are seriously doubted by this writer. While the Philippine populations of *Maticora* are very closely allied to populations of that genus extant in Borneo and elsewhere in western Indonesia and Malaya, the Philippine species of *Calliophis* is only distantly allied to its sole congener in western Indonesia, *C. gracilis*. The distinctness of the Philippine species of *Calliophis* and its restricted distribution in the Philippines (to the western Visayan and Luzon island groups) clearly indicates that the genus attained the Philippines long before the related genus *Maticora*.

Though similar in external appearance, the two genera differ strikingly in the development of their venom glands. These glands are of normal size and placement in *Calliophis*. In *Maticora* they are unique; they are exceedingly elongate and extend far back into the body cavity. In external appearance the two genera may be distinguished easily by color pattern, *Maticora* being striped, *Calliophis* barred on the dorsum, and in the Philippine species of both genera, in longitudinal dorsal scale rows at midbody, *Maticora* having 13, *Calliophis* 15.

The Philippine species of these genera are treated in detail below.

The writer is grateful to Dr. Robert F. Inger, Chicago Natural History Museum (CNHM); Dr. Ernest E. Williams,

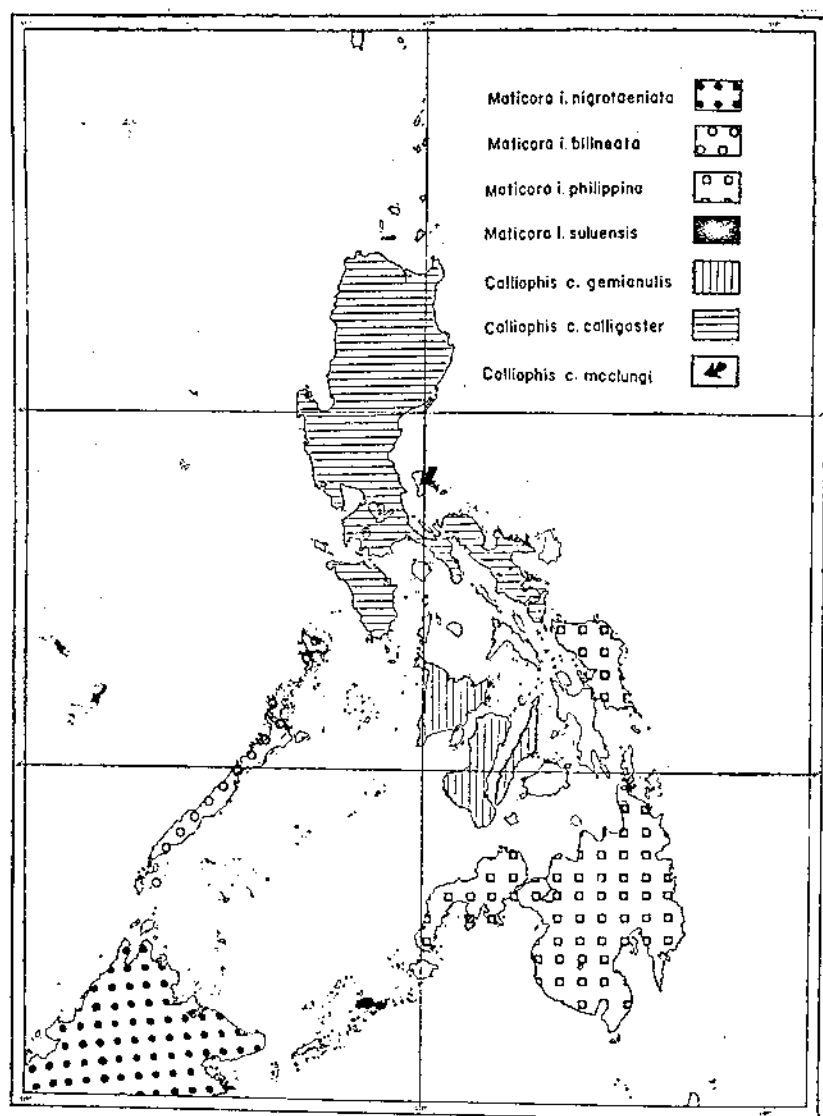


FIG. 1. Distribution of the Philippine species and subspecies of the genera *Maticora* and *Calliophis*.

Museum of Comparative Zoology, Harvard University (MCZ); Dr. Doris M. Cochran, United States National Museum (USNM); Mr. Charles M. Bogert and Dr. Richard Zweifel, American Museum of Natural History (AMNH); and Mr. Nell Richmond, Carnegie Museum, Pittsburgh (CM), for permission to examine specimens under their charge. Thanks

are also due to Dr. Gregorio S. Meyers, Division of Systematic Biology, Stanford University (SU), for reading and criticizing the manuscript as well as for permission to use the Stanford collections.

This work was supported partially by a research grant from the Penrose Fund of the American Philosophical Society of Philadelphia.

TERMINOLOGY

Standard length: distance from tip of snout to anal opening.

*: following locality listed under "Range" indicates specimens were seen from that site.

Scale reduction formula: $15(3 + 4 [90 - 100])$ 13 indicates that dorsal scales reduce from 15 to 13 by fusion of third and fourth rows (on each side) between ventrals 90 and 100.

Genus *MATICORA* Gray

Maticora GRAY 2 (1834) pl. 86, fig. 2 (type species *Maticora lineata* Gray, by monotypy).

Pseudelaps [nec Fitzinger (1826) Reptilia] FITZINGER (1843) 28 (type species *Elaps frucatus* Schneider, by original designation).

Gongylocormus FITZINGER (1843) 28 (type species *Elaps bivirgatus* Kuhl, by original designation).

Doliophis GIRARD (1857) 182 (type species *Elaps flaviceps* Cantor, by monotypy).

Helminthoelaps JAN (1859a) 518 [p. 7 of reprint] [type species *Elaps bivirgatus* Kuhl, by subsequent designation by Stejneger (1922)].

Adeniophis PETERS (1871) 578 (type species *Callophis furcatus nigrotaeniatus* Peters, by original designation).

Aspis [nec Laurenti (1768) Reptilia] BARBOUR (1914) 92 (type species *Aspis intestinalis* Laurenti, by original designation).

Definition.—Maxilla extends forward beyond palatine; venom fangs followed after a diastema by one small tooth; head not distinct from neck; loreal absent; nostril between nasals; eye small, pupil round; body cylindrical, very elongate; tail short; scales in 13 longitudinal rows at midbody; subcaudals paired; venom glands very elongate, extending far back into body cavity, and terminating in an elongate club-shaped end; hypapophyses present throughout vertebral column.

Remarks.—The genera *Calliophis* and *Maticora* as now understood were established by Peters, in 1871, after he showed that there was a very striking difference in the structure of the venom glands between the two groups. Except for this difference, in which the venom glands in *Maticora* extend far back into the body cavity but in *Calliophis* are confined to the

head region, the two genera cannot be distinguished. They are obviously closely related.

Stejneger [(1922) 7-8] reviewed the nomenclatural history of the nominal genus *Maticora* and of its synonyms. I have accepted his conclusions and use the name *Maticora* rather than *Doliophis* of earlier authors [Boulenger (1896) 399, Taylor (1922a) 273, *et alii*].

Nineteen nominal species and subspecies are now included in this genus. Two of these have been listed from the Philippines (*M. bilineata* and *M. intestinalis*); a third, based on a series of specimens from the Sulu Archipelago, had been overlooked by all earlier authors (*M. intestinalis suluensis* Steindachner).

Loveridge [(1944) 106] briefly reviewed the species of *Maticora*. He regarded *M. bilineata* as a subspecies of *M. intestinalis*. *Maticora philippina* was retained as a distinct species, differing from *M. intestinalis* in the proportionally smaller eye. As with other authors, Loveridge failed to account for Steindachner's species.

I have seen specimen of each of the nominal species and subspecies of *Maticora* in the Philippines, and all but one, *M. intestinalis immaculata* Loveridge, from extra-Philippine localities. It is my opinion that the Philippine populations of *Maticora* are conspecific with *maticora intestinalis*, but insular isolation has resulted in the evolution of morphologically distinct geographic populations which are treated herein as subspecies.

Key to the Philippine subspecies of Maticora intestinalis

- 1a. Black crossbars on venter do not come in contact with black of sides; prefrontals, and usually internasals and rostral always white (red in life); dorsolateral light stripe narrow, occupying only parts of the third and fourth, or fourth and fifth scale rows; a distinct white line always present on the sides, occupying the entire first scale row, or parts of the first and second rows. *M. i. bilineata*
- 1b. Black crossbars on venter come into contact with black of sides; prefrontals may or may not be lighter than rest of head; dorsolateral stripe broad, tan to reddish brown, occupying part or all of the fourth, all of the fifth, and usually part of the sixth scale rows; no distinct white line on sides.
 - 2a. Prefrontals cream colored (red in life?), lighter than rest of head; cream crossbars on venter do not extend onto side of body above first scale row *M. i. suluensis*
 - 2b. Prefrontals colored like rest of head; cream crossbars on venter extend onto side of body, often to the fourth scale row. *M. i. philippina*

MATICORA INTESTINALIS (Laurenti).

Aspis intestinalis LAURENTI (1768) 106.

Taxonomic notes.—Boulenger (1896) and Taylor (1922a) recognized two species of *Maticora* in the Philippines, *M. bilineata* and *M. philippina*.

Maticora bilineata has been distinguished from *M. philippina* by its presumably larger eye, and from *M. intestinalis* by having a shorter frontal shield. Both characters have been found to vary considerably. Loveridge (1944) concluded that *M. bilineata* was conspecific with *M. intestinalis*, but differences in color pattern seemed to justify their separation as distinct subspecies.

Maticora philippina has been distinguished from *M. intestinalis* on the basis of its smaller eye. In other characters, *M. philippina* closely resembles *M. intestinalis* from Borneo. Comparison of the ratio for the diameter of eye/distance to mouth (see Table 1) in small series of *M. intestinalis* from several islands indicates: (1) that there is considerable intra-population variation in this character, and (2) that the Philippine sample (excluding those from Palawan) tends to average a slightly smaller eye than samples from elsewhere. The marked similarity between the Philippine and Bornean samples which are distinguished by only one somewhat variable

TABLE 1.—Summary of the variation in the diameter of eye/distance to mouth ratio in *Maticora intestinalis*.

Island	N	Diameter of eye/ distance to mouth	
		Mean	Range
Singapore	3	0.99	0.86-1.10
Pulu Bakong	1	0.93	
Sumatra	9	0.84	0.55-1.00
Pulu Toekus	1	0.79	
Java	7	0.89	0.73-1.40
Borneo	1	0.83	
Jolo	1	0.75	
Mindanao	7	0.69	0.50-0.82
Samar	1	*	
Palawan Archipelago	15	0.88	0.65-1.00

* Specimens too poorly preserved to obtain accurate measurements.

character suggests they are conspecific. In view of the fact that the Bornean population differs from *M. intestinalis* from Java, and elsewhere in relatively minor details of color pattern, it is only reasonable to conclude that the Bornean,

a very distinct white line along the outer scale row, the black crossbars on the venter do not contact the black lateral color, and the light dorsolateral stripe is narrow and occupies parts of two rows of scales rather than the whole of two rows. Specimens from the eastern Philippines (excluding the Sulu Islands) agree with the Bornean form in color pattern, although there is a tendency for the black to be concentrated into rings rather than uniformly distributed over the dorsum. However, the eye tends to be smaller. Lastly, specimens from the Sulu Islands are similar in color pattern to typical Bornean specimens, but they differ in having fewer ventral shields.

In recognition of the differences among island populations outlined in the paragraphs above, the following subspecies of *Maticora intestinalis*² are recognized:

Maticora i. intestinalis—Java and eastern Sumatra

Maticora i. lineata—western Sumatra and Malaya

Maticora i. nigrotaeniata—Borneo, Celebes

Maticora i. bilineata—Palawan and Busuanga islands

Maticora i. suluensis—Sulu Archipelago (Jolo Island)

Maticora i. philippina—Mindanao and Samar islands

It is necessary to remark on the selection of a type locality of the *forma typica*. The type locality of *Aspis intestinalis* was given by Laurenti as "Africa. This is obviously erroneous. According to Laurenti's description, however, it is evident that his specimen belongs to the Javanese-east Sumatran population, for he indicates that the mid-dorsal stripe is bifurcated in front of the eyes:

Corpore aequali tenui; linea longitudinali dorsi, & laterum; dorsali ante oculos bifurcata.

I hereby select the island of Java as type locality of *Aspis intestinalis* Laurenti.

Diagnosis.—Venter usually with an alternating series of black and light crossbars; head, at least posteriorly, dark, sub-caudals 15 to 33. Standard length: (♂) 578 mm, (♀) 505 mm; tail length: (♂) 47 mm, (♀) 40 mm.

Descriptive notes.—Maxillary teeth 1+1 (one fang followed after a diastema by a small tooth); diameter of eye equal to 0.5 to 1.4 times the vertical distance to the mouth; snout rounded; rostral about as broad as deep; prefrontals more

² Loveridge (1944) described *M. intestinalis immaculata* from Sarawak, Borneo, based on a single specimen which differed from typical Bornean individuals in lacking black crossbars on the venter. I strongly suspect that the example Loveridge had before him was abnormal in this character.

than twice as large as internasals; frontal slightly longer than broad, more than two times as broad as supraocular, as long as the distance to the rostral or beyond; nasal large, subtriangular, tapering posteriorly, undivided, with large nostril loreal absent; preocular 1, in contact with nasal and eye; postoculars 2; 1 large anterior temporal; 6 upper labials; third shield highest, third and fourth border orbit; 5 lower labials, the first pair in contact behind mental, the first three shields in contact with anterior chin shields; both pair of chin shields about equal in size; scales in 13 longitudinal rows throughout; dorsal scales reduce 15 (-2 [3-9]) 13; caudodorsal scales reduce 6 (2 + 3 [5-20]) 4; ventral and subcaudal counts see Tables 2 and 3 (counts according to Boulenger [(1896) 402] range as follows: ventrals 197 to 273; subcaudals 15 to 33); anal plate undivided.

Hemipenes extend to twelfth subcaudal plate, forked at tenth plate; sulcus spermaticus unforked; walls of organ uniformly spinose except at basal end.

Color (in alcohol) variable but basically dark brown to black above usually with a light mid-dorsal stripe, a light brown dorsolateral stripe, and frequently a light lateral stripe; below with an alternating sequence of black and light crossbars; tail cream above and below with black annuli. In life the cream-colored areas are probably red.

Inter-island variation.—Inter-island variation in color pattern and diameter of eye versus vertical distance to the mouth have already been discussed (see taxonomic notes above).

Variation in ventral and subcaudal counts cannot be clearly associated with geographic variation in all cases. The lowest ventral counts are found among specimens from the Riou Archipelago and Malay Peninsula and among specimens from the Sulu Archipelago. The Malay-Riou populations have already been distinguished as distinct subspecies on the basis of color pattern, and the tendency toward a lower ventral count may be an additional distinguishing character.

Among specimens from the Sulu Archipelago, one examined here, and sixteen others reported on by Steindachner [(1891) 295], the number of ventrals for both males and females ranged from 197 to 218. The similarity in color pattern obviously relates the Sulu sample to the Bornean population. However, specimens from Borneo as well as elsewhere in the Philippines average 30 to 40 ventrals more than the average of the Sulu Archipelago sample (compare diagnoses of subspecies).

In subcaudal counts the Javanese sample seems to average a slightly lower count in both sexes. The differences, however, are not great, and it is doubtful that any significance can be attached to them.

Body proportions are quite similar for all samples; they are subject to a marked sexual dimorphism. No inter-island variation could be detected in these proportions.

TABLE 2.—Summary of the variation in the number of ventral shields in *Maticora intestinalis*.

Island	Male			Female		
	N	Mean	Range	N	Mean	Range
Singapore	2	222.0	215-229	2	249.5	247-250
Pulu Bakong	1	209.0				
Sumatra	3	231.3	230-233	6	274.7	244-300
Pulu Tockus				1	241.0	
Java	2	251.5	250-253	6	279.5	272-289
Borneo (Kinabato)	1	238.0				
Jolo	1	* 202.0				
Mindanao	5	242.8	236-250	4	248.8	237-258
Samar				1	270.0	
Balabac	1	240.0				
Palawan	8	252.6	236-260	3	275.0	266-285
Busuanga	3	234.0	232-237	1	256.0	

TABLE 3.—Summary of the variation in the number of subcaudal shields in *Maticora intestinalis*.

Island	Male			Female		
	N	Mean	Range	N	Mean	Range
Singapore	2	26.0	26	2	20.3	20-21
Pulu Bakong	1					
Sumatra	3	26.6	26-27	6	21.7	20-24
Pulu Tockus				1	23.0	
Java	2	23.0	22-24	6	19.7	16-22
Borneo	1	24.0				
Jolo	1	** 28.0				
Mindanao	6	27.8	25-30	4	23.5	20-27
Samar				1	21.0	
Balabac	1	28.0				
Palawan	9	28.8	24-31	3	23.6	23-25
Busuanga	2	27.5	27-28	1	25.0	

* This does not include Steindachner's data [(1891) 259].

** Tail damaged.

MATICORA INTESTINALIS BILINEATA (Peters).

Callophis bilineatus PETERS (1881) 109 (type loc: "Palawan" [= Palawan Island]; type in Berlin Museum; original description); BOETTGER (1886) 117 (listed).

Adeniophis bilineatus BOULENGER (1894) 84 (Balabac, Palawan; description); BOETTGER (1895) 5 (Busuanga; counts, distribution).

Doliophis bilineatus BOULENGER (1896) 404 (Balabac, Palawan [Puerto Princesa], Mindanao [doubtful]; synonymy, description, counts); BOETTGER (1898) 124 (Palawan, Culion; listed); (1911) 266 (distribution compiled; listed in key); TAYLOR (1922a) 274, pl. 34, figs. 5-6, pl. 35, fig. 3 (Palawan [Iwahig], Mindanao [doubtful]; synonymy, description, variation, measurements and counts of material examined, common names, distribution).

Maticora intestinalis bilineata LOVERIDGE (1944) 106 (listed in key); LEVITON (1961) 102 (listed in key; Balabac, Busuanga, Culion, Palawan).

Range.³—BALABAC*. Busuanga: Borac Bay*; Sungai*. PALAWAN: Iwahig*; Puerto Princesa*. CULION.

Material examined (18).—BALABAC: without exact locality (CM 2568). BUSUANGA: Borac Bay (SU 13235); Dimaniang (CNHM 53555); Sungai (SU 13234); without exact locality (CAS 62068). PALAWAN: Iwahig (CAS 62169 and 62170); Puerto Princesa (CAS 15814); without exact locality (CAS 62145 and 62146; CM 2569; USNM 38378; CNHM 15018, 15020, and 15021). PHILIPPINES: without exact locality (CAS 15347; CNHM 41120 and 41121).

Diagnosis.—Black crossbars on venter do not come in contact with black on side of body; prefrontals, and usually internasals, rostral and first 2 upper labials white (alcohol specimens); a distinct white line always present on side of body between first and second scale row, or the first scale row completely white; dorsum of tail with two or three black rings, otherwise red or cream but no black. Standard length: (♂) 464 mm, (♀) 431 mm; tail length: (♂) 39 mm, (♀) 28 mm.

Sexual dimorphism.—The small size of the available sample does not lend itself to adequate statistical analysis. Casual

³ Boulenger [(1896) 404] and Taylor [(1922a) 27] include Mindanao in the range of *M. i. bilineata*. Taylor's record is based on that of Boulenger. The latter had before him four specimens of this subspecies, one from Palawan, one from Balabac, and two said to have come from Mindanao. I doubt that *M. i. bilineata* occurs in Mindanao and suspect that the specimens from Mindanao which Boulenger had before him belong to *M. i. philippina*.

examination of the data suggests the sexes do differ in ventral counts, but not in subcaudal counts or point of reduction of the dorsal caudal scales from 6 to 4. This last point is of interest for it suggests that the tails of males and females are essentially of the same shape despite the presence of the paired copulatory organs in the tails of the former.

In the tail length/standard length ratio the differences between sexes are very marked, females have proportionately shorter tails and longer bodies than the males (see Table 4).

TABLE 4.—Summary of variation between sexes in the ratio of the tail length/standard length in *Maticora intestinalis bilineata*.

Sex	N	Mean	Range
Male	13	0.092	0.084-0.097
Female.....	4	0.067	0.065-0.071

MATICORA INTESTINALIS PHILIPPINA (Günther).

Elaps intestinalis var. GÜNTHER (1858) 230 (Philippines; color pattern).

Callophis intestinalis GÜNTHER (1859) 82, pl. 16, figs. A. & a (Philippine Islands; descriptions).

Callophis intestinalis var. *Philippina* GÜNTHER (1864) 349 (Type loc: Philippine Islands; type in British Museum; original description; MEYER (1870) 368 (notes presence of elongate venom glands). *Adenophis philippinus* MEYER (1886) 614 (south Mindanao; remarks; on venom gland and relationships); BOETTGER (1886) 117 (listed); Casto de Elera (1895) 441 (listed).

Doliophis philippinus BOULENGER (1896) 404 (redescription of type specimen); BOETTGER (1898) 124 (Mindanao; listed); GRIFFIN (1911) 266 (Luzon [Manila]; listed in key); TAYLOR (1918) 261 Mindano [Zamboanga City]; listed); (1922a) 277, pl. 35, figs. 1-2 (Luzon [Manila]), Mindanao [Bunawan; Zamboanga]; synonymy, description, measurements and counts of material examined, variation; habits); (1922b) 301 (Mindanao [Zamboanga]; notes on specimen).

Maticora philippina LOVERIDGE (1944) 106 (listed in key).

Maticora intestinalis philippina LEVITON (1961) 102 (Mindanao, Samar; listed in key).

Range.¹—LUZON: Rizal Province (Manila). MINDANAO: Agusan Province (Bunawan*); Davao Province (Todaya*); Lanao Province (Lake Lanao*); Misamis Occidental Province

¹I suspect that the specimens of *Doliophis bilineata* recorded by Boulenger [(1896) 404] from Mindanao belong here.

(Misamis *); Zamboanga Province (Miatan *; Zamboanga City *). SAMAR: without exact locality *.

Material examined (12).—Mindanao: Agusan Province. Bunawan (CM 2579 and 2580). Davao Province: Todaya (CNHM 53557 and 53558). Lanao Province: Lake Lanao CAS 15349). Misamis Occidental Province: Misamis (SU 15984). Zamboanga Province: Miatan, Katipunan (CNHM 68918); Zamboanga City (CAS 62031); without exact locality (CAS 15348). SAMAR: without exact locality (USNM 53536). PHILIPPINES: without exact locality (MCZ 25842 and 25843).

Taxonomic notes.—The type specimen of this subspecies was collected at an unknown locality within the Philippines. Boulenger's description of the specimen suggests it is most similar to a single specimen I have seen from Samar Island. However, the ventral count is very low (three are 18 shields less than the minimum number of shields counted among specimens examined here). The count seems to be closer to specimens from the Sulu Archipelago. In view of the doubtful origin and equally doubtful association of the specimen, I am reluctant to select a type locality at this time. Should an examination of the type specimen indicate that it belongs to the Sulu Archipelago population, then the nominal subspecies, or variety of Günther, *Callophis* [sic] *intestinalis philippinus*, would be conspecific with *Callophis* [sic] *intestinalis suluensis* Steindachner, and a new name would have to be proposed for the population inhabiting the main islands of the Philippine group.

Diagnosis.—Black crossbars on venter contact black on sides; dorsolateral stripe broad, tan or reddish brown; no distinct white line on sides along outer scale row; prefrontals colored as rest of head; cream crossbars on venter extend onto side of body, often to fourth scale row; ventrals 232 to 285. Standard length: (♂) 578 mm, (♀) 505 mm; tail length (♂) 47 mm, (♀) 40 mm.

Descriptive notes.—Diameter of eye/vertical distance to mouth 0.65 to 1.00 (mean = 0.88); frontal about as long as its distance from rostral; ventrals and subcaudals see Tables 2 and 3; dorsal scales reduce 17 (−2 [3–5]) 15 (−2 [6–9]) 13; caudodorsal scales reduce 6 (2 + 3 [5–20]) 4 (1 + 2 [19–28]) 2.

Cream colored crossbars on venter extend onto sides and on occasion touch dorsolateral stripe; 29 to 45 black crossbars on venter, 1 to 3 under tail.

Color (in life) "... above a dark yellowish brown, each scale edged with darker; a median darker line, beginning on neck, continuing the length of body, broken occasionally by a yellowish spot; on either side of this darker median line are 2 lighter stripes, below which the ground color breaks into bands which encircle belly; these narrow ventrally and number 43 on body, with 2 on tail; below, they are dark brown to black, covering 4 or 5 ventral scales, and are separated by orange colored bands, which cover 2 or 3 ventral scales but narrow on sides; they extend usually to fourth row of scales; the irregular series of dim light spots on the median dorsal dark line are between the ends of the light abdominal bands; head brown, with indistinct darker shading; darker between eyes and on tip of snout; a black spot in the middle of sixth labial; chin variously mottled with brown and light; first labials with light spots; a white line crosses sixth labial; chin spotted with dark; bands under tail a brilliant scarlet, much wider than those on belly, almost surrounding tail." [Taylor (1922a) 278.]

Sexual dimorphism.—The most striking differences between males and females of this subspecies lie in the subcaudal counts and in the tail length/standard length ratio. As expected, females have fewer subcaudals and shorter tails (see Tables 3 and 5).

TABLE 5.—Summary of variation between sexes in the ratio of tail length/standard length in *Maticora intestinalis philippina*.

Sex	N	Mean	Range
Male.....	5	0.093	0.084-1.10
Female.....	4	0.068	0.059-0.073

There is no clear difference between sexes in ventral counts; there is an extensive overlap in the range of ventral counts. The mean number of ventrals is slightly lower in males, however, and more adequate sampling will probably demonstrate that the number of ventrals is subject to sexual dimorphism.

Although it was thought that the number of black crossbars on the body might differ between sexes, such has not proved to be the case. In three females the number of crossbars range from 29 to 45; two females from Davao Province range from 29 to 36. The number of crossbars in four males range from 31 to 40 (mean = 38.3).

MATICORA INTESTINALIS SULUENSIS (Steindachner).

Callophis intestinalis suluensis STEINDACHNER (1891) 295 (type loc: Sulu Archipelago; type in Vienna Museum; original description).

Range⁵.—SULU ARCHIPELAGO: Jolo*.

Material examined (1).—JOLO: without exact locality (SU 15983).

Diagnosis.—Black crossbars on venter contact black on side; dorsolateral stripe broad, tan or reddish brown; no distinct white line on sides along outer scale row; prefrontals cream colored (specimen in alcohol), or at least lighter than rest of head; cream colored crossbars on venter do not extend onto side of body above first scale row, ventrals 197 to 218. Standard length: (♂) 372 mm; tail length: (♂) 33 mm.

Descriptive notes.—Diameter of eye/distance to mouth 0.75; frontal equal to length of snout; ventrals 197 to 218; subcaudals 24 to 33; dorsal scales reduce 17 (–2[4–5]) 15 (–2[9]) 13; caudodorsal scales reduce 6 (2 + 3 [17]) 4 (at tip) 2; 39 black crossbars on venter, 3 on underside of tail.

Genus CALLIOPHIS Gray

Calliophis GRAY (1834) pl. 86, fig. 1 (type species *Calliophis gracilis* Gray, by monotypy).

Brachyrhynchus (nec Laport (1832) Hemiptera) FITZINGER (1843) 28 (type species *Elaps calligaster* Wiegmann, by original designation).

Callophis GÜNTHER (1859) 79 (erroneous subsequent spelling).

Hemibungarus PETERS (1862) 638 (type species *Elaps calligaster* Wiegmann, by monotypy).

Definition.—Maxilla extends forward beyond palatine; venom fangs followed by a diastema and then by from 1 to 5 small, solid teeth; head not distinct from neck; loreal absent; eye small, pupil round; body cylindrical, elongate; tail short; scales smooth, in 13 or 15 longitudinal rows throughout; subcaudals paired (rarely single in *C. maclellandi*); hypapophyses developed throughout vertebral column; venom glands confined to head region (compare definition of genus *Maticora*).

Remarks.—Smith [(1943) 419] united *Calliophis* and *Hemibungarus* having shown that maxillary teeth are present in species of *Calliophis* said to have none. According to Smith only *C. gracilis* and *C. maclellandi* lack solid maxillary teeth

⁵ This subspecies is known with certainty only from Jolo Island in the Sulu Archipelago. According to Steindachner, his specimens were collected in the "Sulu Inseln." It is not known whether Steindachner was referring to the whole of the Sulu Archipelago or to Jolo Island, whose old name was Sulu Island. In any event, this subspecies is known with certainty only from Jolo, which island I hereby select as type locality of Steindachner's subspecies.

behind the anterior fangs. I have examined specimens of *C. gracilis* from Kelantan, Malaya, and *C. macclellandi* from Sikim, India and Kosempo, Formosa. In each case a very small, solid maxillary tooth was found a short distance behind the grooved front fang.

Smith [(1943) 418], Boulenger [(1896) 396], and others have used Günther's amended spelling *Callophis* for Gray's nominal genus *Calliophis*. Günther's name by reason of its status as an erroneous subsequent spelling and a junior synonym, does not have any separate status in nomenclature from *Calliophis* Gray, and it must be replaced by Gray's spelling.

Taylor [(1922a) 268-273] included three species of *Hemibungarus* (= *Calliophis*) in the Philippine herpetofauna. Of these, *Hemibungarus collaris* (= *Elaps collaris* Schlegel) was shown by Schmidt [(1937) 362] to belong to genus of South American elapid snakes [see also Thompson (1913)]. He transferred *E. collaris* Schlegel, together with its total synonymy, including *Elaps gastrodelus* Duméril, Bibron, and Duméril (which he did not see), to *Leptomicrurus*. At my request Dr. Jean Guibé of the Museum d'Histoire Naturelle, Paris, re-examined the type of *Elaps gastrodelus* and concluded that it must be placed in the synonymy of *E. collaris* Schlegel (= *Leptomicrurus collaris*) as suggested by Schmidt. *Elaps callisgaster* Wiegmann and *Hemibungarus meclungi* Taylor, the two remaining species recognized by Taylor, and the nominal species *Hemibungarus gemianulis* Peters, which has usually been placed in the synonymy of *Elaps callisgaster*, are properly included in the Philippine fauna.

The three nominal species of *Calliophis* from the Philippines are considered to be conspecific and are treated herein as a single species. However, insular isolation has resulted in the differentiation of the species into three geographically distinct populations; these are accorded subspecific rank.

Key to the subspecies of Calliophis callisgaster

- 1a. Black rings on dorsum of body not divided by narrow white annuli; temporal region heavily pigmented with melanin; white annuli on dorsum usually less than 60.
 - 2a. Ventrals: ♂, 223 to 233; ♀, 252 to 259 *C. c. callisgaster*
 - 2b. Ventrals: ♂, 206 (2 specimens) *C. c. meclungi*
- 1b. Black rings on dorsum of body divided by narrow white annuli; temporal region not heavily pigmented with melanin; white annuli on dorsum usually more than 60; ventral; ♂, 197 to 216; ♀, 218 to 227 *C. c. gemianulis*

CALLIOPHIS CALLIGASTER (Wiegmann).

Elaps calligaster WIEGMANN (1834) 253, pl. 20, fig. 2.

Taxonomic notes.—*C. calligaster* is endemic to the Philippines; at least it has not yet been taken outside of the political boundaries of the Archipelago. It has been recorded from many of the larger islands in the Philippines, and it may be presumed that future collecting will demonstrate its presence on others as well. At present specimens have been collected on Luzon, Polillo, Panay, Negros, Cebu, and have been reported from Mindanao and elsewhere (see footnote 6.)

Specimens of *C. calligaster* from Luzon are characterized by high ventral counts and a color pattern in which the black rings are not divided by narrow white bands on the dorsum, though on the venter these black rings are occasionally divided by white crossbars. The lower portions of the temporal region are heavily pigmented with melanin (absent in young specimens). These characters agree in detail with Wiegmann's description and color plate of *E. calligaster*, based on a specimen said to have come from Manila. The Luzon population, therefore, must be regarded as the typical population.

Panay, Negros, and Cebu specimens have fewer ventrals than those from Luzon; furthermore, the black rings are divided on the dorsum by narrow white annuli which extend onto the venter; and the lower portions of the temporal region tend to lack the concentration of melanin pigment characteristic of the Luzon population. The lack of differentiation among specimens from Negros, Panay, and Cebu permits their grouping into a single "Visayan sample." Peters' nominal species *Hemibungarus gemianulis*, characterized as having black rings and half-rings more numerous than in *H. calligaster* and a whitish temporal region, appears to be based upon a specimen taken from one of these western Visayan Islands.

In 1922a, Taylor described *Hemibungarus meclangi* from Polillo Island. This species was separated from *H. calligaster* because of its lower ventral count, absence of a black interocular bar, and proportional measurements. Taylor's specimen was a juvenile. Unfortunately, it was destroyed in 1942. A second specimen obtained by Taylor, in 1922, on Polillo Island and still in existence bears out some, but not all his conclusions. The existing specimen differs from Luzon individuals in its lower ventral count. It does not differ in proportional measurements or in color pattern. The single character serving

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In 1922a, Taylor described *Hemibungarus mcclungi* from Polillo Island. This species was separated from *H. calligaster* because of its lower ventral count, absence of a black interocular bar, and proportional measurements. Taylor's specimen was a juvenile. Unfortunately, it was destroyed in 1942. A second specimen obtained by Taylor, in 1922, on Polillo Island and still in existence bears out some, but not all his conclusions. The existing specimen differs from Luzon individuals in its lower ventral count. It does not differ in proportional measurements or in color pattern. The single character serving

to differentiate *H. macclungi* from typical *H. calligaster* certainly does not suggest specific separation.

It should be noted that Taylor's description of *C. calligaster* is based upon an individual from Panay Island; his illustrations (Plate 33, figs. 1 and 2, and Plate 34, figs. 1 and 2) are obviously of Luzon specimens.

Diagnosis.—Scales in 15 longitudinal rows throughout; 6 supralabials (rarely 7); anterior temporal in contact with 2 upper labials; preocular in contact with nasal; color pattern consists of an alternating series of broad black and red rings which are separated by narrow white annuli (in the adult the dorsal and lateral portions of the red rings become heavily suffused with black pigment. Standard length: (♂) 519 mm, (♀) 476 mm; tail length: (♂) 32 mm, (♀) 28 mm.

Descriptive notes.—One large venom fang followed after a considerable diastema by a small, solid tooth; rostral broader than deep; internasals smaller than prefrontals; frontal longer than broad, equal to or slightly longer than its distance from snout, 1.5 times as broad as supraocular, shorter than parietals; latter shields in contact with upper postocular only; nasal large, divided, in contact with at least 2, but more frequently 3 upper labials and with preocular; nostril large, between two nasals; 1 real absent; 1 preocular; 2 postoculars; 2 anterior temporals, the upper shield in contact with both postoculars, the lower with 2 upper labials; 6 upper labials, rarely 7, the third and fourth bordering orbit; 7 lower labials, the first pair usually in contact behind mental, the first four in contact with large anterior chin shields; scales in 15 longitudinal rows throughout; caudodorsal scales reduced from 6 to 4 near tip of tail; ventrals and subcaudals see Table 6 or account of subspecies; anal plate single.

Hemipenes extend to the seventh or eighth subcaudal plate, forked near tip; proximal two-thirds spinose, the spines of moderate and subequal size throughout; distal third calyculate, with minute spines set into margins of calyces.

Color (in alcohol); snout, nasal, and first 2 upper labials creamy yellow; dorsum of head (in adults) reddish brown to black, this color extending onto the third and fourth upper labials and may extend onto the temporal shields; a white postocular bar almost reaches the frontal, and a white stripe, originating at the angle of the jaws, passes forward and upward and ends either at or on the parietals. In the young

the dorsum of the head is cream, with a black interocular bar (very rarely absent), and occasionally a black median longitudinal stripe on the parietals present; the black rings on the body, which may or may not be divided by narrow white annuli, alternate with an equal number of black crossbars (red or cream in young specimens, and red or cream on the venter in adults) and are separated from the crossbars by narrow white annuli.

Ontogenetic variation.—Most pronounced in this species is the notable change in coloration which occurs during development of the individual from juvenile to adult. In young specimens, arbitrarily considered as individuals less than 270 mm in standard length, there is an alternating series of black and cream (in alcohol specimens, red in life) rings. These rings lack melanin pigment which invades the area in the adults. There is little melanin in the frontal, parietal, and temporal regions of the head, other than the concentration in the form of an interocular bar and nuchal chevron. The adults contrast sharply with the young for the dorsal portions of the red or cream rings become heavily infused with melanin as do also the shields of the posterior portion of the head.

TABLE 6.—Summary of the variation in the number of ventral shields in *Calliophis calligaster*.¹

Island	Female			Male		
	N	Mean $\pm$ S.D.	Range	N	Mean $\pm$ S.D.	Range
Luzon	9	254.3 $\pm$ 2.27	249-259	15	227.5 $\pm$ 3.11	223-233
Polillo				1	206	
Mindoro				1	231	
Negros	8	223.4 $\pm$ 2.85	218-227	8	208.8 $\pm$ 4.33	202-216
Panay	1	224		3	197.3	196-199
Cebu				1	201	

¹Includes data only from specimens examined. Literature records are excluded.

Inter-island variation.—Specimens from Panay, Negros, and Cebu islands appear to form a homogeneous group and are treated as a single sample. Specimens from Luzon, and a single recorded individual from Samar Island, reported by Peters [(1861) 689], constitute a second sample. The Polillo Island sample is based upon two specimens, one of which is no longer in existence.

Variations occurs in the amount of pigmentation in the temporal region and in the tendency for the black rings to be divided on the dorsum by narrow white annuli. Specimens

from Luzon, Polillo, and Samar do not have the black rings paired on the dorsum, though a short white crossbar may divide these rings on the venter. Specimens from Negros, Panay, and Cebu, on the other hand, have paired black rings, though the white annuli which divide the black rings may become somewhat obscure in large adults. As a result there is marked difference in the number of white rings present in the dorsal color pattern between the Visayan sample and those from other islands (see Table 7). The number of white rings for the entire sample of *C. calligaster* averages 63.6. If the Luzon and the Visayan samples are treated in a 2×2 contingency table, i. e., the number of specimens having more than 65 white annuli and the number having less than this number from each sample, the differences between the Visayan and Luzon samples prove to be statistically significant (see Table 8).

TABLE 7.—Summary of variation in the number of white annuli on the dorsum of the body in *Calliophis calligaster*.

Island	N	Mean $\pm$ S.D.	Range
Luzon	12	51.0 $\pm$ 5.33	44-75
Polillo	1		46
Visaya (Negros, Panay, Cebu)	15	75.8 $\pm$ 2.32	60-83

TABLE 8.—Analysis of variance in the number of white annuli on the dorsum of body in two samples in *Calliophis calligaster*.

	Luzon	Visaya
White annuli > 65	1	14
White annuli < 65	11	1

$$\text{Chi-square} = 12.7 \quad (\text{Yates' correction})$$

$$P = < 0.01$$

No significant differences could be detected in the number of black rings in the samples being compared providing the paired rings in specimens of the Visayan sample are treated as if they were undivided.

As previously noted the amount of melanin pigment present in the temporal region also varies. Excluding young specimens, of 16 Visayan specimens exhibiting the adult color pattern, only 2 showed a tendency to darkening in this area. Of fourteen Luzon specimens having adult coloration, all were heavily pigmented in this region. This was also true for the single Polillo specimen available for study.

TABLE 9.—*Determination of sex of specimens examined by Boulenger in Calliophis calligaster.*

Specimen number ¹	Boulenger		Battersby ²	
	Sex	Ventrals	Sex	Ventrals
a'	♀	219	♂	222-1
'b-d'	♀	235	♂	234-1
	♀	229	♂	229-1
	♀	260	♀	257-1
c'	♀	221	♀	223-1

¹ After Boulenger [(1896) 393].² Data kindly supplied by Mr. James C. Battersby who re-examined the specimens for me.TABLE 10.—*Determination of sex of specimens examined by Taylor in Calliophis calligaster.*

Specimen number *	Locality *	Stated * sex	Ventrals *	Sub- caudals *	Sex should be
21	Luzon	♂	228	21	♂
22	do	♀	236	23	?
23	do	♂	233	19	♂
25	do	♂	250	23	♀
26	do	♀	216	29	?
27	do	♀	251	20	♀
28 **	do	♂	257	19	♀
.....	do	♀	222	19	♂
40 **	do	♀	256	12	♀
41 **	do	♀	228	20	♂
54 **	do	♀	224	20	♂
231 **	Panay	♂	197	20	♂

* After Taylor [(1922a) 270 and (1922c) 300].

** I have examined these specimens. Specimen 28 is at the Chicago Natural History Museum; specimens 40, 41, and 54 are in the California Academy of Sciences; and Number 231 at the Carnegie Museum, Pittsburgh.

There is, in addition, a marked inter-island variation in ventral counts. Overlap in counts between Luzon females and Visayan males necessitated treating the sexes separately. It is evident from a cursory inspection of the data summarized in Table 6 that the differences in ventral counts between Luzon, Visayan, and Polillo Island populations are pronounced.

To avoid future controversy, it must be pointed out that previously published data on ventral counts for this species are confused. This results from the fact that many of the specimens were incorrectly sexed. For example, comparison of

my results correlating sex with ventral counts led me to suspect both Boulenger [(1896) 393] and Taylor [(1922a) 270 and (1922b) 300] incorrectly sexed their specimens. At my request, Mr. J. C. Battersby of the British Museum (Natural History) kindly re-examined the specimens reported on by Boulenger. His findings and those of Boulenger are compared in Table 9. It is evident that Battersby's data agree closely with those obtained by me, with one exception. Specimen 'e', a young female, 340 mm in total length, said to have been collected at Albay, southeastern Luzon, appears to be abnormal, assuming the locality datum is correct.

In regard to the data given by Taylor [(1922a) 270 and (1922c) 300] it is also obvious that the stated sex of several of his specimens are questionable (assuming his locality data are correct). I have had the opportunity of seeing several of his specimens and can confirm that they were incorrectly sexed. In Table 10, I have summarized Taylor's data and have indicated where there is disagreement as to the sex of individual specimens.

CALLIOPHIS CALLIGASTER CALLIGASTER (Wiegmann).

Elaps calligaster WIEGMANN (1834) 253, pl. 20, fig. 2 (type loc: Manila, Luzon Island; type in Berlin (?): original description; colored figure); GÜNTHER (1858) 231 ("Philippine Ids.": synonymy, color pattern); JAN (1859a) 6 ("Carthagene N.-Grenade" [in error]; pattern); PETERS (1861) 689 (Luzon [Daraga; Vulkan Ysarog; Albay]: listed); JAN (1873) Livr. 43, pl. 2, fig. 2.

Brachyrhynchus calligaster FITZINGER (1843) 28 (listed).

Elaps collaris var. *calligaster* DUMÉRIL, BIBRON, and DUMÉRIL (1854) 1226 (Luzon [Manila]: synonymy, diagnosis, description, color pattern; considers *E. collaris* Schlegel conspecific with *E. calligaster* Wiegmann).

Elaps calligaster JAN (1859b) 5-6 [LUZON (Manila): correction of locality error in (1859a) 6].

Callophis calligaster GÜNTHER (1859) 84 ("Philippine Ids.": listed); FISCHER (1885) 81 ("Süd-Mindanao": listed).

Hemibungarus calligaster MEYER (1869) 213 (not seen); BOETTGER, (1886) 117 (distribution compiled); CASTO DE ELERA (1895) 440 (Luzon [Bataan; Manila; Camarines Sur; Daraga] Mindanao, Paragua, Balabac); BOULENGER (1896) 393 (in part: Luzon [Albay]: synonymy, description, color pattern; counts; material examined); BOETTGER (1898) 122 (Luzon; listed); GRIFFIN (1911) 266 (distribution compiled; adds Luzon [Rizal; Laguna], Polillo; listed in key); TAYLOR (1922a) 269, pl. 33, figs. 1-2; pl. 34, figs. 1-2 (in part: distribution compiled; synonymy, measurements and counts, variation, material examined; description and color pattern based upon specimen of *C. calligaster gemianulis*); TAYLOR (1922b) 300 (Luzon [Los Baños]: measurements and counts for three specimens).

Calliophis calligaster calligaster LEVITON (1961) 100 (Luzon; listed in key).

*Range.*⁶—LUZON: Albay Province (Albay; Daraga); Bataan Province (Bataan); Camarines Sur Province (Mt. Isarog); Laguna Province (Los Baños*; Mt. Makiling*); Quezon Province (Villa Aurora*) Rizal Province (Binanga*; Manila; Montalban*). MINDORO: San José*.

Material examined (18).—LUZON: Laguna Province; Los Baños (CAS 61136 to 61142; CNHM 15050); Mt. Makiling (CAS 61314; CNHM 45751); Quezon (Tayabas) Province: Villa Aurora (USNM 142483); Rizal Province: Binanga (CAS 15343 and 15344); Montalban (CAS 15009; USNM 38663). MINDORO: San José (AMNH 73415). Without exact locality: USNM 37421, 56057 and 56058. PHILIPPINES: without exact locality (CAS 15342).

Diagnosis—Black rings on body not divided by narrow white annuli; narrow white rings on dorsum of body number 44 to 75; temporal region more or less heavily pigmented with melanin, with a distinct light vertical postocular stripe and a diagonal nuchal chevron bordering the area; ventrals 223 to 259; subcaudals 16 to 22. Standard length: (♂) 487 mm, (♀) 476 mm; tail length: (♂) 28 mm, (♀) 28 mm.

Sexual dimorphism—There is marked sexual dimorphism in ventral counts as evidenced in Table 6. The range of ventrals for males is 223 to 233 (mean = 227.7), and for females 252 to 259 (mean = 255.0).⁷

A clear distinction in subcaudal counts between sexes is not evident though females average fewer shields than males suggesting possible sexual dimorphism. Nine males range from 17 to 22 (mean = 19.9); 6 females range from 13 to 30 (mean = 17.6).

Body proportions are also subject to sexual dimorphism. The difference in the tail length/standard length ratio between sexes is obviously significant, although the means are close and there is some overlap in ranges (see Table 11).

⁶*Calliophis calligaster* has been reported from Balabac, Paragua, and Mindanao by Casto de Elera, and from Mindanao by Fischer. These records need confirmation.

⁷Previous literature records of ventral counts have been omitted from these ranges for reasons already given (see page 541).

TABLE 11.—Summary of the variation between sexes in the ratio of tail length/standard length in *Calliophis calligaster calligaster*.

Sex	N	Mean $\pm$ S.E.	Range	Difference of means	t	P
Male	8	0.0577 $\pm$ 0.0013	0.0522-0.0633	0.0075	3.47	<0.01
Female	6	0.0502 $\pm$ 0.0018	0.0373-0.0577			

Ecological notes.—Little is known of this animal's habits. A single specimen, CNHM 45751, was found burrowed in the earth in the dipterocarp forest on Mt. Makiling. According to Taylor [(1922c) 300] several specimens were found at low altitudes on Mt. Makiling. Locality data for other specimens suggest the individuals were found principally at or near sea level.

The stomachs of all individuals examined but one (AMNH 73415) were empty. The one contained a single *Calamaria gervaisi*. This is in agreement with observations made on the Visayan sample, and it appears that these animals are ophiophagus.

No data are available on breeding habits.

CALLIOPHIS CALLIGASTER GEMIANULIS (Peters).

Hemibungarus gemianulis PETERS (1872) 587 (type loc: "Philippine Ids."; type in Berlin: original description).

Callophis (Hemibungarus) gemianulis MÜLLER (1883) 18 (listed).

Hemibungarus gemmianulis BOETTGER (1886) 117 (listed); CASTRO DE ELERA (1895) 441 (Mindanao).

Calliophis calligaster gemianulis LEVITON (1961) 100 (Cebu, Negros, Panay; listed in key).

Hemibungarus calligaster BOULENGER (1896) 393 (in part; "Philippines"; synonymy, description, counts, material examined); TAYLOR (1922a) 269 (in part; Panay [Iloilo]; synonymy, description, variation, measurements and counts, material examined, distribution).

Range *.—CEBU: Antuwanga area *. NEGROS: Negros Occidental Province (La Carlota *); Negros Oriental Province (Dumaguete *; Batingil *; Silay *). PANAY: Iloilo.

Material examined (24).—CEBU: Antuwanga area (SU 18909). NEGROS: Negros Occidental Province: La Carlota

* Casto de Elera [(1895) 441] records a specimen from Mindanao, but I doubt his record.

(USNM 80579). Negros Oriental Province: Dumaguete (SU 7243, 12969); Batingil Sitio (SU 19005); Silay (USNM 78136 to 78148). PANAY: Iloilo (SU 12966 to 12968, CM 2581).

Diagnosis.—Black rings on body divided by narrow white annuli; white annuli on dorsum number 60 to 83; temporal region either light (cream or reddish in color) or very lightly (spotted with melanin; ventrals 196 to 227; subcaudals 15 to 21. Standard length: (♂) 519 mm, (♀) 451 mm; tail length: (♂) 32 mm, (♀) 28 mm.

Sexual dimorphism.—As already noted in the typical population there is a marked difference between sexes in ventral counts. This is also true for the Visayan population; 12 males range from 196 to 216 (mean = 205.2); 9 females range from 218 to 227 (mean = 223.4). There is in addition a more pronounced difference between sexes in the Visayan sample in subcaudal counts than was evident in the sample from Luzon: 11 males range from 18 to 21 subcaudal plates (mean = 20.4); 9 females range from 15 to 18 plates (mean = 16.8).

The Visayan sample also shows sexual dimorphism in body proportions. The data for tail length/standard length ratios, summarized in Table 12, indicate that males have somewhat longer tails in proportion to body length than do females (the young of both sexes tend to have slightly longer tails in proportion to body length than do the adults).

TABLE 12.—Summary of the variation between sexes in the ratio of tail length/standard length in *Calliophis calligaster gemianulis*.

Sex	N	Mean $\pm$ S.E.	Range	Difference of means	t	P
Male	8	0.0679 $\pm$ 0.0016	0.0592—0.0707	0.0900	5.57	<0.01
Female	8	0.0583 $\pm$ 0.0020	0.0465—0.0628			

Ecological notes.—Of the 24 specimens examined, and literature record of one specimen, only two specimens were found to have anything in their stomachs. These individuals, USNM 78139 and 78147, contained partially digested remains of a *Calamaria gervaisi* and a *Typhlops* sp., respectively. Nothing else is known of their food habits, or indeed, of any other aspects of their ecology. They undoubtedly are secretive animals likely to be found beneath the logs and underbrush.

CALLIOPHIS CALLIGASTER MCCLUNGI (Taylor).

Hemibungarus sp. GRIFFIN (1910) 214 (Polillo; listed).

Hemibungarus mcclungi TAYLOR (1922a) 272, pl. 33, pl. 34, figs. 3-4 (type locality: Polillo Island; type formerly in Bureau of Science, Manila, but destroyed during Word War II [neotype designated below] original description, relationship to *H. calligaster* discussed); (1922b) 300 (Polillo [on road to Bislian]; scutellation, color in life).

Calliophis calligaster mcclungi LEVITON (1961) 100 (Polillo; listed in key).

Range.—POLILLO*.

Material examined (1).—POLILLO: on road to Bislian (CAS 62431).

Taxonomic notes.—The loss of the holotype of this nominal subspecies means there is no standard available for comparison. To insure stability in the application of Taylor's name to the population for which it was intended, I am selecting the only other specimen of the Polillo population presently in museum collections, California Academy of Sciences 62431, to stand as the neotype. It is eminently suited as a replacement for the lost holotype inasmuch as it comes from the type locality and is identical to the lost type in sex, body proportions, and color pattern. The neotype is described below.

Diagnosis.—Black rings on body not divided above by narrow white annuli; narrow white rings on body number 46 (white tends to be obscured by black); temporal region pigmented; ventrals 206.

Description of neotype (CAS 62431).—Young male; standard length 270 mm; tail length 23 mm. Dorsal scales in 15 longitudinal rows at midbody; ventrals 206; subcaudals 23. Upper labials 6 (on right side; left side damaged), third and fourth bordering eye; 1 preocular; 2 postoculars; temporals 1 + 2. Dorsum with 23 black rings, each ring divided below by a distinct whitish bar, each also narrowly edged anteriorly and posteriorly with whitish (which is sometime obscured by black); black rings separated from each other above by brownish interspaces and below by cream (red in life?) bars. Dark interocular bar, absent in holotype, is present; otherwise head color pattern as in Luzon population.

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A HISTORICAL REVIEW OF GOLD IN THE PHILIPPINES

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INTRODUCTION

No metal has played such a fateful and peculiar role—for good and evil—in the history of mankind as gold. Almost without intrinsic value, soft and useless for implements of any kind, the yellow metal has nevertheless been coveted, searched for, fought for, and amassed in various forms ever since—some 6000 years ago—it was first discovered and extracted in the ancient centers of civilization. For thanks to its other unique properties, its luster and brilliancy emulating the sun, its untarnishable incorruptibility and its beauty, in short its glamor, it came to be considered a divine substance, a symbol of permanence and immortality. Owing to its scarcity it also became for its possessors a token of power and wealth, and it was, therefore, adopted as the standard by which property and commodities were valued, long before metallic currency came into use.

In the course of history the use and extraction of the yellow metal spread over the globe and the demand for it rose continually for jewelry and ornamental purposes and particularly for mintage. But while it thus retained its lure and attractiveness all over the civilized world, its cult as a magic substance was superseded by more advanced religions and gradually fell into oblivion. Only among primitive peoples in remote regions did the ancient worship survive, until they were invaded by the gold-thirsty white man at the time of the great voyages of exploration during the 15th and 16th centuries.

Such was the situation in the Philippine Islands at the arrival of the first Spanish expeditions, and thanks to the detailed reports of their officials and priests we are able to catch a glimpse of the ancient quaint customs and beliefs then still lingering among the native inhabitants, of their

primitive methods of extraction, of their craftsmanship and of the role of the metal in their trade. From that time on the vicissitudes of the metal can be followed by means of a wealth of documents and reports.

From the exposé given in the following pages it will also appear that—save for some virgin placers—the Philippine gold deposits have not, during the period here under review, yielded any easy and excessive profits, and few people have ever been able to accumulate a fortune derived from them. But this was not inherently the fault of the deposits themselves; it was due to the undeveloped state of mining and metallurgy. The gold of the quartzveins is only partly free-milling and what could be recovered by the simple panning methods of those days was only a portion of that part; all the rest of the gold, often more than half of the values, was left in the tailings. Yet we are bound to admire the skill and perseverance both of the thousands of Filipinos washing the alluvials and of the Igorots in the mountains who for many centuries successfully extracted gold where all the Spaniards' attempts failed completely. It was only by the introduction of modern dredging, mining and milling methods—above all cyanidation—that the gold could be effectively extracted from such ores. But thanks to these improvements the industry has been able during the present century to acquire an increasingly important position in the economic life of the Islands.

These modern developments, however, lie outside the scope of this narrative which is confined to Spanish, and to some extent pre-Spanish, times and which therefore terminates with the end of the 19th century.

GENERAL CONSPECTUS

When the first Spanish expeditions—headed by Magellan (1521), Loaisa (1525–1526), Saavedra (1527), Villalobos (1543), and Legaspi (1565)—arrived in the Philippine Islands, they found gold produced and extensively used by the natives of practically every island. "All the people, both great and small wear it." (17) "Wherever we went we found a great display of these articles." (10) The people, in particular their chiefs, wore gold earrings, bracelets, necklaces, anklets, (3, 7, 10) men as well as women. (46, 63) The chieftains of Cebu wore clasps about their feet. (12) The people often besides wore "gold

pieces, not merely of thin plate, and brooches to fasten them." (46) Pigafetta, Magellan's historian, noticed that the natives of Butuan (Mindanao) had "holes pierced in their ears which are filled with gold." (3) He also tells us that the "king" of Butuan had "three spots of gold on every tooth, and his teeth appeared as if bound with gold," (3) and Chirino confirms that the people "used to and do yet insert gold between their teeth as an ornament." (46) Colin also states that "among the influential people, especially the women, it was the custom to set some of the teeth most skilfully with gold which could not fall out." (64)

Pigafetta gives a detailed description how "the males, in Cebu, large and small, have their penis pierced from one side to the other near the head, with a gold or tin bolt as large as a goose quill," (3) and Morga reports the same peculiar custom at Catanduanes. (49)

Gold articles were buried with the dead. (12) The corpses were embalmed and gold placed in their mouth and over their eyes. (49) Colin states that "in memory of their ancestors they kept certain very small and very badly made idols of stone, wood, gold, or ivory." (64) Pigafetta claims that occasionally even the house of some chieftains had some parts made of gold. (3)

Most of these customs were gradually abandoned during the Spanish regime, but still in 1662 Letona (63) reports that "there is hardly an Indian who does not possess chains and other articles of gold."

Gold was the general standard of currency, both in the inter-tribal and external commerce. The people of the present Mountain Province of Luzon (Igorots) bought most of their food for gold from the tribes of the surrounding valleys and lowlands. (34) The punishment for crimes was fine, payable in gold and jewelry or, if the delinquent was unable to do so by slavery. (34) The bridegroom paid the dowry to the bride's parents in gold, jewelry, pearls, and slaves. (34) Already Pigafetta (3) records the fact that the people were fond of cockfights, and Buzeta and Bravo (81) tell us that at the start of such fights each better deposited his stakes in gold dust. Trading vessels from Borneo often plied the waters round the Philippine Islands, and junks from China and Japan arrived during the winter monsoon with products of their countries. (3) The main article coveted by these foreign traders was gold. Magellan's

men were offered gold in exchanged for trinkets, iron, and merchandise.(3)

The skilfulness of the natives in weighing,¹ appraising and adulterating the metal, as well as their proficiency in the jeweller's art, aroused the admiration of the Spaniards.

The people of this island (Luzon) are very skilful in their handlings of gold. They weigh it with the greatest skill and delicacy that has ever been seen. The first thing they teach their children is the knowledge of gold and the weights with which they weigh it, for there is no other money among them.(37)

They even recognize whence the gold comes as soon as they see it, and they say that this gold comes from such an island and this other gold from such another.(17)

Although they trade but little, they . . . know how to adulterate it by mixing it with silver, tin, copper, brass, and other metals brought from China . . . its quality is tried by a touchstone and in this the Moros seem to be more skilled than the Spanish assayer who has been taken from Mexico.(31)

They give it an outside appearance so natural and perfect and so fine a ring, that unless it is melted they can deceive all men, even the best of silversmiths.(18)

In Luzon the following alloys of gold were distinguished, the finess of which may be gauged from certain data: *bietu* or *bizlin* and *malubay* about 10 carats fine and *linguingin* about 13 carats fine, were used for trade and barter; *panica*, called *orejeira* (earrings) by the Spaniards, about 16 carats fine; *ylapo* about 20 carats, and *guinuguran* or *guinogulan*, "lord of gold," about 22 carats, were used for jewelry.(25, 31) "This last is the standard, because in assay it is equal to the wrought gold of Spanish jewelry." (25) A report from 1586 states that in Camarines "there are many excellent goldsmiths after their fashion. Those men roam the island in order to gain their living. Many interesting things made by them are taken to Mexico, especially filigree work." (37) In 1573 governor de Lavezaris sent to the king and queen of Spain 136 marcos (about 27 kg) of such articles.(21) Still in 1662 Letona mentions that "various articles are exquisitely wrought in filigree of gold and silver," (63) and slender chains for personal adornment continued to be shipped to Mexico more than half a century later.(68)

The universal use of gold by the inhabitants for personal adornment cannot be explained as exclusively due to a mere childish vanity and urge of display and of beautifying

¹ The Igorots of Central Luzon, however, were said to have traded gold by sight only.(55)

themselves. It had also primarily a deeper significance. The burial of such ornaments with the dead and the custom of placing gold in the mouth and over the eyes of the corpses conclusively prove that peculiar magical powers were attributed to the metal. Here—as was also the case with all the ancient civilizations of the Orient—gold must have been considered a divine substance, conferring longevity upon its possessor.⁽¹⁰⁰⁾ And the people must have worn their ornaments in the belief that they were powerful talismans, capable of protecting them from dangers and evil spirits. Sande mentions that “they adore the gold—which they actually kiss and consider of the highest importance,” although he wrongly interprets their feelings as avarice.⁽³¹⁾

Moreover, the multifarious uses and widespread diffusion of gold, noticed by the early Spaniards entitle us to infer that the metal was no novelty, recently introduced among the tribal peoples of the Philippine Archipelago. This inference is also corroborated by the widespread production of the precious metal in the Islands. Not only were the auriferous sands of practically every river-system already being exploited, but all the important vein-gold districts were likewise known and worked to a considerable extent. The Spanish pioneers found mines at Masbate worked to a depth of one to two estados (3.4 to 6.8 m),⁽²³⁾ and those of Paracale in Camarines to a depth of 30 to 40 estados (50 to 70 m).⁽¹⁹⁾ And even if the latter figures may be much exaggerated, the statement proves that mining there must have been carried on for a long period prior to the arrival of the Spaniards. The same pioneers also learned about the existence of the gold mining regions of the present Mountain Province, where the Igorots inhabiting that country were trading their gold for food from the populations of the surrounding provinces. The remoteness and inaccessibility of that region, and the proud and warlike race inhabiting it, defied for about fifty years more the efforts of the Spaniards to explore it. And when, in 1624, they finally succeeded, they could only establish the fact that the Igorots were skilful miners and far more advanced than the Spaniards themselves in the extraction of gold from the ore.

But when and whence had the knowledge of the yellow metal, the ideas of its magical potency, and the art of extracting it been introduced? To this question as yet only a tentative answer can be given. For our knowledge of Philippine history of the periods antedating the Spanish conquest is very scant,

as there are very few written records and monuments which, moreover, have to be looked for among those of the neighboring countries that were culturally more advanced.

A good summary of what is known has been given by Forbes: (85)

What are believed to be authentic sources indicate that the islands now known as the Philippines were a dependency of successive Hindu-Malayan empires in Indo-China, Sumatra and Borneo, from about the year 200 AD until 1325. Thereafter until 1405, they were subject to the Javanese empire of Majapahit. During the next 35 years they were, under the Ming Dynasty, a dependency of China. Thereafter, from the year 1440 until 1565, northern Luzon was sometimes held by Japanese adventurers, and from Manila southwards the islands were dominated by Mohammedan Borneo.

Hence it is apparent that the islands, which have been populated by successive waves of predominantly Malay immigrants coming from the southwest, must have received cultural elements from many different sources.

But while in India, Indo-China and China gold mining and extraction are of great antiquity, it appears that in the Philippines this industry—although established long before the Spanish conquest—was a much later introduction. First, it is notable that gold, which in practically every report of the early Spaniards figures as one of the chief products of the Islands, is not mentioned at all among their articles of export in the Chinese geographer Chao Ju-kua's report, dating from about 1280 A.D. (2) On the contrary, there is an item on his list of imports called "commercial gold." Chao, for some years superintendent of the sea-trade in Fukien Province, had access to first-hand information from the captains and crews of the vessels engaged in the trade with the Islands. He indicates the places visited, describes the awkward methods of bartering with the natives and enumerates the various articles exchanged. It appears that the port of call in Luzon (Ma Yi) was probably situated at the mouth of the Pasig River, thus at the site of present Manila, and that the expeditions were also extended to the Visayas and to northern Mindanao. The products of the Islands are stated to have been; yellow wax (aromatic resin), cotton, pearls, shells, betel nuts and jute textiles (abaca), while the articles brought into the country were: porcelain, commercial gold, iron vases for the perfumery, lead and tin objects, glass, pearls of all colors, iron needles, and fish nets. The gold

probably comprised both dust and ornaments and, possibly, even Siamese gold coins.

These data prove beyond doubt that while gold was already known and appreciated in the Islands, it was not yet produced there. The fact that there was already a demand for the yellow metal seems to indicate that the gold cult may have antedated the actual discovery of its occurrence in the Islands. The earliest known gold article of apparently local manufacture has been dated by Professor H. Otley Beyer to about 1350 A.D.(101) It is a massive image of a Buddhist deity, found about 1920 in the Agusan River, near Esperanza in Mindanao. The statuette is over 20 cm in height, of 21 carat gold and weighs 1,790 gr. The style, according to Beyer, resembles that of the Ngandjuk period of Javanese art, but since the workmanship is cruder and the color—a very pure yellow—as well as the quality, are distinctly different from the metal employed in such work in Java, Beyer concludes that the statuette was locally made by Javanese artisans. Hence it may be inferred that gold production in the Philippines probably commenced early in the fourteenth century. The style of the statuette also indicates the probable route of introduction of the art (India-Java-Borneo), an inference which is strengthened by the fact that the weights used at the time of the Spanish occupation for weighing gold are of Indian origin (the tae, the maes and the condareen; see p. 595). From India too, must have come the idea of the magic significance of gold. It may also deserve mentioning that the Malayan languages have a common indigenous word for gold, while the names of several other metals, such as silver and copper, are of Sanskrit origin.(86)

There must have been a veritable rush of prospectors combing the Islands in search of rich placers, and the art of panning thus spread like a fever among the native population. Skilled artisans also probably arrived in the wake and the wearing of gold ornaments and mascots, formerly a privilege of the few, now became available to almost everybody. The old mines found by the early Spaniards must have been the work of professional miners, presumably immigrants from the same quarter or possibly Chinese.

In spite of the abundant display of gold ornaments that met the eyes of the Spanish conquistadores, it soon, however, became evident to them that the actual stocks possessed by

the Philippine natives were not large, and that their expectations of duplicating here the enormous booty of gold taken in Mexico and South America, were not going to be realized.²

Rada(17) noted in 1569 that

"no one of these Indians has more than a little gold, for if they get a couple of earrings and a couple of bracelets and a pair of anklets for their feet, they do not look for any more, for they do not strive to hide it."

Legaspi(16) observed at about the same time that the natives "because of their sloth and the little work done by their slaves, . . . do not even try to become wealthy nor do they care to accumulate riches. When a chief possess one or two pairs of earrings of very fine gold, and a chain, he will not trouble himself to look for any more gold. Any native who possess a basketful of rice will not seek for more, or do any further work, until it is finished."

The lack of covetousness and the sloth of the people, however, were not the only reasons responsible for the absence of any large hoards. The trade with China, Borneo, and Japan had been going on for centuries,(2) and ever since the production of gold started, this trade had resulted in a constant outflow of the yellow metal. At the time of the Spanish conquest, the Mohammedan Malays, called Moros, roamed the islands in order to trade with the Chinese and Japanese whose junks arrived regularly with the monsoon every year, bringing silks, woolens, bells, perfumery (musk, benzoin), wine, iron, tin, porcelain, colored cotton clothes and other small wares.(15) Moreover, most of the auriferous alluvials and the gold mines were worked spasmodically, only on certain occasion for the sole purpose of producing the amount necessary to buy some particular goods brought by a trading vessel lying at anchor at a nearby harbor.

The procedure varied somewhat, as appears from the following quotations:

Although there are many mines and much pure gold, yet the natives do not extract it until the very day they need it; and even then they

² The statements contained in a letter by an anonymous writer in Sevilla, which was printed in Spain in 1566,(11) must be considered a mere sailor's yarn. The writer affirms that the inhabitants of Cebu hold gold in so little estimation and possess such enormous supplies of it the "king" there gave three barchillas of gold dust (about 55 liters) or say 700 to 800 kg; for one string of hawk's bells. He claims moreover, that three Spanish vessels loaded so much gold in that island that the royal fifth amounted to 1,200,000 ducats. The authoritative reports quoted elsewhere in this paper tell quite a different story.

take only the amount necessary for their use, thus making the earth their purse.(10)

In many places where we know that mines exist, the natives do not care to work them, because they say that their god orders them not to take out the gold except on the arrival of foreign vessels for purposes of barter. They strike a bargain with those foreigners and allow them to work in the mines for a period agreed upon.(10)

If perchance any merchant junk comes to trade, the natives buy all the goods on credit, after which, in order to pay, all the village assembles and goes armed to the placer or to the mines, in order that no one will dare to touch them, and accordingly they get the gold that they have to give.(17)

Whereas the drain of gold to other Oriental countries had—apart from occasional piratical raids—proceeded by a peaceful exchange of commodities, the inhabitants had now come into contact with, and were being subjugated by, a race that in its aggressiveness and gold-thirst did not stop short of violent means to get possession of the coveted metal. A similar spectacle, as had been recently enacted in the Americas, was now being repeated here, although on a much smaller scale. So-called pacifying expeditions were sent out to all accessible parts of the islands, and under the pretence of collecting tribute on behalf of his royal Majesty, the greedy Spanish commanders and soldiers ruthlessly robbed the people of their gold ornaments, cherished by their possessors not because of their commercial value but with religious awe and worship of their life-giving powers. The conduct of the soldiery was largely denounced by the Catholic friars and priests accompanying those expeditions, and it is to their outspoken accounts that we owe our knowledge of what actually took place.

The following words of Ortega (20) give the story in a nutshell:

The only gold being in the shape of personal adornments worn by the natives, this is demanded from them as a tribute, while refusal or flight is punished with death.²

² Ortega's report in full runs as follows:

It is fitting that your Excellency should know the manner in which these tributes are collected, and the way in which they are demanded before the time, contrary to the law of God and the directions of his Majesty. The first thing they do when they reach any village or province is to send them an interpreter or two, not with gifts or presents, not to preach to them or to speak to them of the things of God, but to order them to bring tribute immediately and to be friendly

(Continued on page 560, bottom.)

Of the quantities of gold thus extorted from the natives in the name of the Crown, only a part was actually handed over to the treasury, while as much as half of the plunder was divided privately among the soldiers. Besides such official expeditions, private ones were also undertaken, raids with the sole object of looting, even graves being dug open and rifled.

(Footnote 3—Continued.)

to the Castilians. Since this is so new and strange thing for them as being something to which they have not been accustomed, as they have not been either subjects or vassals of any native king or lord (of whom they have none in any part of these islands), all this is confusion to them and causes them much evil by forcing them to give as tributes the necklaces which they wear about their necks and the bracelets which they and their women wear on their arms. For few or none of them have any other property but what they wear on their persons. When these so evil abuses are inflicted upon them, some of them refuse to give the tribute or do not give as liberally as those who ask it desire. Others, on account of having to give this and of their fear at seeing a strange and new race of armed people, abandon their houses and flee to the tingues (i.e. hills) and mountains. When the Spaniards see this they follow them, discharging their arquebuses at them and mercilessly killing as many of them as they can. Then they go back to the village and kill all the fowls and swine there and carry off all the rice which the poor wretches had for their support. After this and after they have robbed them of everything they have in their miserable houses, they set fire to them. In this way they burned and destroyed more than four thousand houses in this expedition to Ylocos and killed more than five hundred Indians, they themselves confessing that they committed that exploit.

Rada(17) thus describes one of these expeditions:

The governor immediately (after the departure of the ships) sent Captain Juan de Salcedo accompanied by Captain Pedro de Chaves and some men to pacify the river of Vicor (Bicol) and the Camarines which are located in the same island of Luzon. The people there are the most valiant and best armed of all these islands. Consequently, although they never attacked the Spaniards, still they defended themselves in all their villages, and would not surrender unless conquered by force of arms. Consequently all those villages were entered in the same way, by first summoning them to submit peacefully, and to pay tribute immediately unless they wished war. They replied that they would first prove those to whom they were to pay tribute, and consequently the Spaniards attacking them, an entrance was made among them by force of arms, and the village was overthrown and whatever was found pillaged. Then the Spaniards sent to have the natives summoned to submit peacefully. When the natives came, they asked them to immediately give them tribute in gold and to give them writs of peace. Therefore, since all the people defended themselves, more have perished in that land than in any other yet conquered.

This outrageous practice was, however, strongly denounced by Governor Legaspi, the conqueror of the Islands, a humane and considerate man who in 1565 issued a proclamation⁽¹³⁾ prohibiting the opening of any graves without the permission of his Excellency, and ordering that

"all who have opened graves whence they have abstracted gold, jewels and other valuables, and those who have in their possession gold and jewels of these islands, however they may have been obtained, shall appear and make full declaration before his Majesty's officials . . . under penalty . . . besides losing all the gold and other valuables . . . be proceeded against in due form of law."

This praiseworthy attempt to check the rapacity of the soldiery and establish law and order, however, probably had little effect. Legaspi's own grandson, Juan de Salcedo (born about 1549 in Mexico, dead 1576 in P. I.), one of the ablest commanders who has been called "the Cortez of the Philippines," seems to have been as zealous and unscrupulous tribute collector as anyone else. (Cf. previous footnote.)

Although practically every accessible place was ransacked, the spoils of gold were, for reasons already given, comparatively small, particularly when contrasted with the enormous booty taken by the early conquistadores in the American continents. The following data culled from contemporary reports, will give an idea of the amounts of tributes exacted.⁴ Salcedo, according to Ortega's report⁽²⁰⁾ on his expedition to the gold mines of Camarines and neighboring portions of the east coast of Luzon, collected 800 taes (25 kg) of gold in tribute.

⁴ For comparison, and as a contrast, some figures regarding the booty of the Spanish conquistadores in America may be given. The treasures obtained by Cortez in Mexico, on his initial campaign against Montezuma, comprised 162,000 pesos of gold (680 kg). After the conquest of the Aztek capital, Tenochtitlan, the booty did not exceed 130,000 castellanos (650 kg) while according to another source it was 380,000 pesos (1,550 kg) of gold. In South America Pedro de Heredia, governor of Cartagena (in present Colombia), in 1533 devoted himself to the rifling of numerous tombs, which he carried on almost as a mining industry, and found in many of them as much as 15,000 to 20,000 pesos (63 to 84 kg) of gold articles; one of them, the tomb of a great chieftain, contained 100,000 pesos (420 kg) of fine gold. During his first expedition Heredia is said to have accumulated 1,500,000 pesos (6,300 kg) of gold. In 1532, when Francisco Pizarro looted the camp of Inka Atahualpa at Cajamarca (in present Peru), he took 80,000 pesos (336 kg) of gold, 7,000 marcos (1,600 kg) of silver and 12 emeralds, the

(Continued on page 562, bottom.)

Of this amount he gave half to the soldiers and the other half to his Majesty's treasury. Three months later his alferéz, who had remained behind, brought back a thousand taes (31 kg) of gold, in addition to as many more which he shared between himself and his soldiers.(20)

Some time afterwards the governor, Guido de Lavezaris who had succeeded Legaspi upon the latter's death in 1573, sent an expedition to explore Ilocos and Pangasinan on the west coast of Luzon. Salcedo was put in command of 130 soldiers, with 830 natives to row the boats. This expedition collected in tribute 300 taes (93 kg). Here Spanish soldiers continued their depredations twice a year and are said to have collected in 1573, 6,000 taes (19 kg).(22) Out of this tribute 136 marcos of gold (30 kg) were sent to the king and queen of Spain.(21)

After the natives had thus been deprived of whatever gold articles the Spaniards could lay hands upon, the only way to secure a steady supply of the desired metal was to encourage and organize production and to check and regulate as far as possible the outflow of it to other Oriental countries and direct it to the Government coffers instead. The government would then get their lawful share of the output, partly by levying the usual production tax in kind—the so-called royal fifth—and partly by making the personal head tax of the inhabitants (the so-called tribute) payable in gold in all districts where gold occurrences were available for extraction.

(Footnote 4—Continued.)

booty being mostly in the shape of bowls, cups, chargers, etc. belonging to the Inka's household. Some time later, when the treasures collected at his order from all the temples and palaces of his vast kingdom to ransom his life, were counted, they were found to amount to the huge total of 1,326,539 pesos (5,550 kg) of fine gold and 51,600 marcos (12,000 kg) of silver. The loot later taken at Cuzco, the capital of the empire, aggregated 580,200 pesos (2,430 kg) of gold and 215,000 marcos (49,000 kg) of silver. In 1536-1538 Gonzalo Jimenez de Quesada took in the Chibcha kingdom (in present Colombia and Venezuela) 191,294 pesos (800 kg) of fine gold, 37,280 pesos (156 kg) gold of inferior quality, and 18,390 pesos (77 kg) of gold mixed with copper, besides 1,815 emeralds among which were many large and beautiful ones. Much gold had been concealed by the Indians by burying it. In 1577 Garcia de Toledo discovered such a treasure at Chimú, on the west coast of Peru, valued at 278,000 castellanos (1,400 kg), the fifth of which was duly paid to the Crown. In 1797 another big hoard was unearthed. Put together these items make up a total of about 18,000 kg of gold.—The above data have been culled from Humboldt (93, IV) and Nordenskiöld.(97)

This, however, proved no easy matter. The confidence of the inhabitants in the fairness and justice of their conquerors had been thoroughly shattered by the depredations of the Spanish soldiery, and the civil officials too were largely guilty of treating the natives arbitrary and rudely. The Filipinos, having lost all sense of security, found it to be more to their advantage to reduce their gold production to a minimum, and to produce clandestinely the gold they needed for ornaments, amulets, and barter. And to avoid being pressed into service and sweated by Spanish overseers at the placers and mines, they preferred to hide and cover up as far as possible their knowledge of any profitable occurrences. In this latter policy they even received the secret support of the Spanish religious, who denounced the cruelties perpetrated by their own countrymen.⁽⁵¹⁾

Since the arrival of the Spaniards in the land, the natives proceed more slowly in this (gold production) and content themselves with what they already possess in jewels and gold ingots, handed down from antiquity and inherited from their ancestors.⁽⁴⁹⁾

In order to counteract this tendency and to encourage production the government in 1578 reduced the royal fifth to one tenth, at first for a period of ten years, but the reduction was successively extended so that in effect it remained valid for more than a century.^(15, 60) Moreover, from Mexico was introduced an important technical innovation, the "arrastre," a crushing device to be described later in this article. And, as already intimated, the tribute or head-tax, usually amounting to 8 reals per person (27 gr), was to be collected in gold in the main gold regions of the islands.^(30, 52)

To begin with, however, these measures failed to achieve their purpose, and the gold production continued to decline. They failed not only because of the passive resistance of the natives, but for other reasons as well. First, the extent and richness of many mines and placers were gradually found to fall far short of expectations. Secondly, the ordinance requiring the payment of tribute in gold, soon lost its intended effect of compelling the inhabitants to produce the required amount of gold locally. For after Manila had become the monopolistic center of the trade between Mexico and the Orient—importing articles from Oriental countries, mainly China, and exporting the same articles to Mexico, where they were sold at enormous profits—a stream of Mexican and Peruvian silver was flowing

into the Philippine Islands, where this trade became the main source of private as well as public revenue. Consequently, it was no longer necessary for a man to wash his tribute out of the river sand or the crushed quartz vein; it was often easier to earn the money by doing some odd jobs.(42,36)

Gradually the government realized that they could not rely to any great extent on gold production as a source of fiscal revenue, although opinions vary between rather wide limits among the early writers. Captain Diego de Artieda(23) in 1573 reported that Mindanao, contrary to its fame, was very poor in gold and that

"the Spaniards who went there were able to find but little, or to be more accurate, none. According to what I have learned, all the gold mines of this island are so poor, that the natives offer their labor for a gold maes (3 gr) or three reals per month, . . . a slave can be bought for fifty reals (6 silver pesos) or sometimes for a little more. It is therefore evident that it is not possible to save from the mines much gold, as can be seen by any man who zealously wishes to serve your Majesty."

He found that the mines of Masbate "yield very little on account of the scanty population, its trade is of slight value." Luzon is stated to have "many rivers in which gold is found—although, as I have ascertained, in but little quantity."

In summarizing his opinion of the islands as a whole Artieda says: "There are few islands where, as it is reported, gold does not exist—but in so small quantities." Lavezaris,(21) on the other hand, states about Luzon "that it contains many rich gold mines," and Rada(17) was "convinced that (God helping), there will be abundance of gold extracted by them (the natives)." The concensus of opinion, at first in favor of Rada's prediction, appears to have gradually swung over to Artieda's point of view.

Although it is true that the gold industry never acquired any preponderance in the economy of the Islands, there soon again came a turn for the better. After about half a century of decline—the bottom of the slump was reached in the first decade of the 17th century—gold production was on the upgrade again. Several causes were responsible for this turn of the tide. First, the excesses against the native inhabitants committed by the Spanish invaders during the first subjugation of the Islands were forgotten as the generation of eyewitnesses passed away, the attitude of the govern-

ment having meanwhile become more humane, benevolent and protective. To quote Bourne:(1)

The ravages of the first conquistadores took place before the Crown had time to develop a colonial policy. . . . The colonial legislation provided elaborate safeguards for the protection of the Indians. Particularly the Philippine Islands stand out in marked contrast with the fate of the aborigines in North America, New Zealand and Australia.

The result of this general policy—in spite of many departures from it by individual officials—was the reestablishment of confidence and a sense of security among the natives. The benevolent attitude of the government towards them may be well exemplified by the fact that shortly after the discovery of important new gold veins in Camarines(82) a royal decree was issued on September 22, 1636, enjoining the local officials to safeguard the right of the natives. And when in 1668, governor Diego de Salcedo despatched an expedition for the final subjugation and christening of the Igorot country, the commander of it was specially instructed to treat the natives humanely and considerately, and these orders were apparently obeyed, the more easily as nothing was found to seriously tempt the avarice of the invaders.(65) And, as proved by the sad fate of the populations in the mining regions of Spanish America, the Filipinos certainly have more reason to be grateful than otherwise over the fact that no sensationally rich gold deposits were ever discovered in the islands.

Another contributory cause to the revival of the native gold industry was the increase of population that went hand in hand with the establishment of relative law and order. This meant an intensified struggle for existence and compelled an expanding number of people to resort to gold mining for a livelihood.

A further powerful stimulant to the gold industry was the total abolition of the royal tithe in the 18th century. This may be concluded from a statement of Governor Anda y Salazar in 1768:

"after so many years in which so much gold has been produced in the islands, this precious metal makes no acknowledgment to its king in Filipinas by paying him the tenth, nor is it weighed in a mint, nor is it by any other expedient made useful to his Majesty, for the religious orders, the Indians, the Spaniards and the mestizos make free use of this trade." (71)

Thus the gold production went on slowly expanding, although it probably seldom yielded any large individual profits to the

miners. Particularly the accessible placers were worked and, as set forth in the sequel, the output gradually rose until the peak was reached shortly after the middle of the 18th century. But with the gradual exhaustion of the richer placers and the easily accessible superficial portions of high grade lodes, the returns were becoming meagre and the output again declined during the latter part of the 18th and the whole of the 19th century. During the last decade of the latter the first attempts at mechanical installations were made with the object of making extraction from poorer grades of placers and lodes profitable. These efforts, however, were limited to Camarines, where a small river dredge was put in operation at Paracale, while two stamp mills with concentrating plants (cf. p. 590) were erected for the crushing and treatment of vein quartz. But the outbreak in 1896, of a general insurrection put a sudden stop to these incipient modern mining activities, and conditions in the islands remained chaotic until order was finally restored under the American flag.

METHODS OF EXTRACTION

It has been mentioned that the Spanish pioneers of the 16th century found the Filipinos far advanced in the art of gold extraction both from placers and lodes. Most of the early Spanish writers clearly distinguished between these two classes of deposits. So did Rada⁽¹⁷⁾ in 1569: "All of them (the Islands) in general yield gold, some more, others less, partly from the rivers and partly from the mines." Herrera, in 1573, reports gold deposits "both in mines and native deposits and placers in the rivers in almost all parts of the land."⁽²²⁾ In the same year the viceroy of Nueva España (Mexico), Martin Enriquez memorialized the king (basing his statements on information received through four officials recently returned from the P.I.) that "there are many gold mines worked similarly to the silver mines here (in Mexico)."⁽²²⁾ Sande,⁽³¹⁾ in 1577 and Loarca ⁽³⁴⁾ in 1582 distinguished between "gold mines and placers where gold is washed." That Salcedo in 1571 found mines in Camarines (Paracale) of considerable depth has already been mentioned, and it will also be related how Quirante, in 1624, found many old, abandoned and caved in workings in the Baguio region.

The methods of the Philippine natives for recovering the gold from placers and lodes were primitive and closely similar

to those of other peoples at the time; in fact, such methods were essentially the same all over the world. The early Spanish writers seem to have left no complete, detailed descriptions of the implements and operations of the natives, but some pertinent features mentioned in their reports may be referred to here. More detailed accounts of these methods are found in reports from the 17th, 18th and 19th centuries, and since there was certainly very little change and very few innovations introduced, we may infer that even the later descriptions in the main represent the original methods as learned from the immigrating Indo-Malayan gold prospectors. Although these methods as practised by the Philippine natives were hardly in any way superior to those of the Spaniards, it is clearly implied in several reports that the former were more skilful in the practice of washing and panning.

It also appears from the early reports that gold digging was not a specialized profession carried on more or less continually by certain individuals. There was little division of labor; the people were agriculturists, and a bountiful tropical nature easily yielded the means of sustenance. Therefore, as set forth in the foregoing, gold mining was engaged in spasmodically, on certain occasions as demand arose, and by practically every member of the household, old and young. Such occasions were particularly the visits of foreign trading vessels, when gold was needed for purchasing the clothing, pottery and trinkets then offered for sale. The only exception to this rule were the Igorots of the Mountain Province, who carried on mining in a more persistent way, compelled by a more sterile nature to acquire part of their food by barter.

After the Spanish occupation, conditions gradually changed. While the sporadic gold output from most of the centers of production declined for reasons already explained, a class of more or less professional miners or mining laborers arose at some of the deposits where the Spaniards concentrated their efforts at gold production, such as Camarines Norte. There gold mining was organized by influential and wealthy Spaniards and mestizos, who employed natives as miners on contract, or at daily wages, or undertook to purchase the gold extracted by them. As time went on, quite a large portion of the population there came to depend on gold extraction for their livelihood, both at Paracale and Mambulao. In periods of prosperity, when some rich strike had been made, there

was probably a busy life, while at other times when resources were meagre and scant, there was unemployment and distress. Quite commonly, in many places in the Islands, even the religious and the administrative officials, the local priest and alcalde, engaged in the gold business, buying the gold brought to them by the natives. The miners and panners, having to labor continually in water are stated to have suffered much from the ill-effects of their occupation. "It is true that this mode of life shortens the days of these wretched people; as they are perpetually in water, they swell and soon die." (73)

The most primitive mining methods were those of the Igorots, described by Quirante (55) as follows:

The tools with which those Ygolotes worked, or work, their mines are certain stakes of heavy wood fashioned like pickaxes, with the knot of the said stake larger at the end of it, where, having pierced it, they fit into it a small narrow bit of iron about one palmo long. Then seated in the passages or works, as the veins prove, they pick out and remove the ore, which having been crushed by a stout rock in certain large receptacles fixed firmly in the ground, and with other smaller stones by hand, and having reduced the ore to powder, they carry it to the washing places. For that purpose they have some small streamlets near at hand, with two or three hollows in their beds. There passing the said ore from one to the other until they clean away the mud from it, by means of the sunlight, which floods everything, they discover and collect some dust or grains of gold. Then they again crush the large grains of ore, and wash and rewash it, until, having passed through the said basins, what remains at last is entirely useless. To judge by the tools that have been seen and which the said Ygolotes have, as above said, the most usual and only working that they give their ores is the above, and nothing further.

Hence it appears that the methods of the Igorots were laborious and primitive in the extreme. There is no mention of firesetting for breaking the rock and of mechanical installations for washing the crushed ore.

Much more advanced was the placer mining of the Moros of the southern island, Mindanao. In fact the people had developed a sort of hydraulic mining. Their methods there at Cariaga, Davao, are described by Bowring: (80)

"they cut in the top of a mountain a basin of considerable size, and conduct water to it by canals made of the wild palm; they dig up the soil while the basin is filling, which is opened suddenly, and exhibits for working any existing stratification of gold; these operations are continued till the pits get filled with inroads of earth, when they are abandoned; generally when a depth has been reached which produces the

most advantageous returns, the rush of waters conveys away much of the metal which would otherwise be deposited and collected."

Very similar methods, described by Eddingfield,(84) were still in use in the eighties of last century in the Cansuran district, Surigao.

While the methods employed by the natives were very crude, they were able to recover a large percentage of the gold from the gravels. They carried water, sometimes several hundred meters by means of flumes made of the bark of trees, the most durable flumes being made of palma brava. Even a very small stream of water enabled them to do very extensive work. The water was led to the top of the face of the gravel to be worked and allowed to flow down it. The gravel was loosened by bars or shovels and was washed down through a narrow trench which in places had to be cut through the bed rock. The light material was allowed to wash away, but the gravel, which accumulated in the trench, was raked and picked by hand and finally thrown up on one bank with coconut shells. The boulders were piled on one side of the trench, forming a wall which retained the waste. Boulders too large to be moved by hand were drawn out or to one side by means of a rattan rope which wound upon a post set vertically, guyed firmly with rattan, and fitted with one of two horizontal arms. Boulders too large to be moved in this manner were left in place and worked around. At regular intervals the concentrates in the bottom of the trench were panned to recover the gold.

In places where water could not be obtained, tunnels were driven along the bed rock and rich gravels were carried down to water and panned. Some of these workings are very extensive, undermining large areas.

Very similar methods at Misamis are described by Abella.(76)

How primitive were the mining operations carried on by the natives in Camarines as late as 1860 has been witnessed by Jagor:(89)

The workmen make holes in the ground 2½ foot long, 2½ feet broad, and 30 feet deep. . . . The rock is carried out of the holes in baskets, on ladders of bamboo, and the water in small pails; but in the rainy season the holes cannot possibly be kept free of water, as they are situated on the slopes of the mountain and are filled quicker than they can be emptied. The want of apparatus for discharging water also accounts for the fact that the pits are not dug deeper.

Whereas the mining and panning methods of the natives, which were almost the same as those of the early Spaniards, remained practically unchanged throughout the Spanish era, two improved crushing devices were introduced in Camarines: the trip-hammer and the arrastre. The former is described by Jagor thus:(89)

The breaking of the auriferous rock is effected by two stones of which one serves as an anvil, the other as hammer. The former, which is slightly hollowed in the center, is laid flat upon the ground; and the latter, $8 \times 8 \times 8$ inches in dimensions, and therefore about 25 pounds in weight, is made fast with rattan to the top of a slender young tree, which lies in a sloping position in a fork, and at its opposite end is firmly fixed to the ground. The workman with a jerk forces the stone that serves for hammer down upon the auriferous rock, the elasticity of the sapling raising it again for a fresh blow.

The rock having thus undergone a preliminary crushing by the trip-hammer is then milled in the arrastre. Jagor's description, with some slight alternation and additions, is quoted below:

A circular bed of rough-hewn stones, about 1.8 m in diameter, is laid out on the ground and is enclosed by a cylindrical wall of similar stones standing on end, about 0.30 m high. From the center of the bed rises a stake provided at its top with an iron pin serving as a pivot, around which revolves a horizontal beam or lever. This latter consists of a tree trunk, pierced in the middle, and both ends of which are bent down towards the bed of the arrastre. To this beam are fastened several heavy stones, bound firmly to it, by rattan, and when turned round by buffaloes harnessed to it, the stones are dragged round on the bed. In this manner the broken rock, which has been mixed with water, is ground to a fine mud. The output of such a device is stated to have been from one to three tons a day.

Remnants of arrastres and anvil-stones are frequently met with in the Mambulao-Paracale region. Jagor continues:

The further treatment of the fine mud from the arrastres was done by women on a most primitive sort of riffle-boards. These consisted merely of a small wooden sluice, at certain intervals provided with cross-slats directed obliquely downwards from both sides towards the center of the sluice, where a narrow gap permits the water to pass through from one slot to the next one, so that a very slender stream flows evenly spread across the whole width of the board, at the lower end of which is a complete cross-cleat. In front of each cross-slat a woman in a kneeling posture spreads with her hands the auriferous mud over the board. When the light sand has been washed away, there remains a concentrate, consisting mainly of iron minerals, quartz and gold dust. This mixture is taken up from time to time with a flat piece of wood and laid on one side. At the end of the day's work it is further concentrated by being panned in a flat wooden dish called batea or faberie. At last it undergoes the final concentrating process in a coconut shell; a soapy vegetable sap extracted from the gogo, a climbing mimosa (*Entada purseta*) is added to prevent the fine gold dust

from floating. It should also be mentioned that the lumps of ore directly coming from the mine, before crushing are rinsed in water in order to remove the gold contained in the mud adhering to them.

At the placers of Camarines some primitive dipper dredges, with a tread-mill device for the dipper, were in use. They are capable of handling two or three cu m per day.(101)

There are no direct statements in the reports about the use of amalgamation at any of the Philippine deposits, but it seems likely that this process was introduced by the Spaniards. Grau y Montfalcon in 1637(60) mentions that quicksilver is brought to the islands in great quantities by Chinese, and this was probably largely used for amalgamation purposes, although another use was for amulets. Dampier(66) also mentions that quicksilver was imported from Lima (Peru).

As for the values recovered from placers and veins some words may be added, although information on this point is naturally very scant. No doubt, the virgin placers were in many places extremely rich, considering the intensity of erosion and transportation of debris in a rugged country with a moist tropical climate, and the widespread occurrence of veins and stringers in practically every drainage area.

However, there is only one scrap of vague information regarding their actual yield in early Spanish time. It is a statement by a dato (chief) Bahandil, about 1580, to the effect that in the Tirurei River (Cotabato) the output of a man per day was from 2 maes to $\frac{1}{3}$ tael (7 to 17 gr), quite a high figure.(33)

In the present century the alluvials of Cansuran (Surigao) yielded Peso 15.60 (12 gr) from 7.5 cu m of gravel, daily for one miner with three assistants, corresponding to Peso 2 (1.6 gr) per cu m.

In Camarines, where intense placer-mining had been carried on for centuries, dredging grounds were found early in this century returning P2.48 per cu m, although the average did not run higher than P0.52.

The alluvials of Misamis were reported by Abella(76) to have yielded from 0.62 to 3.52 gr per ton, out of a total gold content of 0.76 to 5.91 gr.

As for the values extracted from quartz veins, they have naturally been very variable, from thousands and hundreds of grams per ton in rich stringers down to the limit of profitable mining under existing conditions. Samples from Benguet in 1624 assayed by the Spaniards⁽⁵⁵⁾ yielded 22 gr on the average (cf. p. 583). The main vein in Mambulao averages about 10 to 15 gr, although soft stringers may contain much more.

The gold dust obtained by washing was poured into the shells of a bivalve mollusk (*Cardium*). These shells were placed in potsherds and covered with some charcoal. The coals were kindled and fanned by a woman blowing through a bamboo pipe until the metal melted. In this way small ingots were obtained.⁽⁸⁰⁾

Apparently this was the state in which the metal produced at places near the coast—where there was an abundant supply of such shells—was finally marketed. The inland gold was probably sold as dust. There are no hints in the Spanish reports about any sort of refining operations, although such processes were known to several Oriental peoples in ancient time.⁽⁹⁵⁾ The metal obtained by the natives during early Spanish time varied in fineness from 10 to 22 carats, or say 400 to 900 (cf. p. 554). Viana⁽⁷⁰⁾ in 1765 mentions that gold from 18 to 22 carats was circulating in the market. Bowring⁽⁸⁹⁾ in 1859 states that 'its fineness seldom exceeds 16 carats. The metal alloyed with the gold is predominantly silver, with minor amounts of iron. The gold produced by dredging in Camarines during the first quarter of the present century was around 850 fine and contained 133 of silver. Jagor⁽⁸⁹⁾ gives an analysis of a gold ingot obtained by him at Camarines: gold 774, silver, 190, iron 5, and silver 30.

The metallurgical operations of the natives seem to have been directed more to adulterating, than to purifying the metal extracted. In this art they are stated to have excelled, and metals for alloying were specially imported from China (cf. p. 554).

ESTIMATED GOLD PRODUCTION

On the basis of the scattered data found in the Spanish reports it is possible to arrive at a rough approximation of the production of gold during the pre-Spanish and Spanish eras.

As already mentioned, the stocks of gold possessed by the natives at the time of the Spanish conquest were not large,

and what the Spanish pioneers exacted as a first "tribute" may not have totalled more than 500 kg (cf. p. 562), a very small amount when compared to the quantities that had been extracted and exported to China during the two odd centuries of gold production preceding the advent of the Spaniards. Nor does the figure given above represent the total of the existing stocks, for a larger part of them had probably been concealed and had escaped detection. The total of these stocks may, therefore, be tentatively estimated at say 1,500 kg.

For an estimate of the quantity previously exported to the neighboring countries, particularly China, some data given in the early Spanish reports may serve as a guidance. Morga⁽⁴⁹⁾ claims that during the first years of Spanish occupation the tithes collected by the government used to amount to more than 10,000 pesos (gold) (40 kg) apart from tribute gold, and that much gold was also hidden and smuggled out. According to Peñalosa⁽³²⁾ and Loarca⁽³⁴⁾ one single galleon in 1582 carried to Mexico 2,000 marcos (442 kg) of gold. And since gold extraction was an industry at that time rather hampered than stimulated by the Spanish conquerors, it may be safely concluded that the output had previously been larger than the above data indicate. If it be supposed that the native production of gold had, from its inception in the 14th century, let us say two centuries previous to the Spanish conquest, risen evenly from zero to 500 kg it would have been on the average at least 200 kg annually. To avoid the danger of exaggeration it may, however, be assumed that the average was only half of the above, or 100 kg, an amount which, considering the rich virgin placers, does not seem excessive.

The production during the earliest period of Spanish rule may also be gauged from the data given in the preceding paragraph. After 1582 there was a rapid decline owing to the discouraging effect of the importation of Mexican silver. In 1584 the tithes are reported to have been only 4,000 gold pesos⁽³⁵⁾ corresponding to a production of 160 kg. Yet the galleon *Sta. Ana*, which was captured on November 4, 1587, by the English buccaneer Thomas Cavendish,⁽⁷⁾ carried 122,000 pesos of gold (about 488 kg). This export was, however, soon reduced to an insignificant amount of wrought articles, since Mexico herself, along with other American countries, started to produce a large surplus of the yellow metal. The bulk of the Philippine output was, therefore, again diverted to China, whither it went in payment of the Chinese goods which

the Manila merchants bought for transshipment to Mexico. In 1598 the output had shrunk so that both tithes and tribute together amounted to less than 1,000 pesos or 4 kg,⁽⁴²⁾ corresponding to a production of less than 40 kg. And in 1608 the tithes aggregated only 800 pesos or 3.2 kg,⁽⁴⁸⁾ as a consequence of the greatly diminished output from the Igorot mines. But this marks the bottom of the slump; in 1621 production was on the upgrade again, 2,000 pesos of tithes being collected.⁽⁵²⁾ With the growth of population and the sense of comparative security that was gradually established, gold mining seems to have continued to expand during the 17th and 18th centuries, partly because of the fact that the tribute was reduced from 8 to 5 reals.⁽⁶³⁾ And a great stimulant was the total abolition of the tithe. From a report⁽⁹⁵⁾ of 1765 we learn that

"the gold which the infidels bring down from the mountains there (in Pangasinan) . . . exceed 300,000 pesos (dures, or silver) and with that which is brought from other provinces reaches 500,000 pesos."

Montero y Vidal⁽⁷²⁾ also states that in the period 1764-1800 the gold obtained from the placers used to amount to 200,000 pesos. The gold equivalent of 500,000 pesos duros is about 900 kg which seems to be the peak production of the whole pre-American period. It is true that still higher figures are given by an anonymous Englishman (who was apparently a keen observer),⁽⁷³⁾ describing conditions in 1819-1822, but to be on the safe side we will assume that he was guilty of exaggeration. He stated that the amount of placer gold "obtained by the rude efforts of the natives, merely washing the sands of the torrents, is very great, and certainly does not fall short of 400,000 to 500,000 dollars (silver pesos) worth annually."

Buzeta and Bravo⁽⁸¹⁾ in 1851 give 100,000 pesos as the yearly output of placer gold in Luzon alone, and if the gold from the Mountain province and other sources is included, the total may have been more than the double of this figure. During the latter half of the century production gradually declined, as the richer placers were being exhausted and the mines were reaching a depth at which unwatering and hoisting or haulage became a serious problem. From data given by Centeno⁽⁸³⁾ in 1876 the gold output at that time may have been slightly over 100 kg. The disorder prevailing during the

* Although importation of silver pesos from Mexico commenced already about 1580, gold pesos were retained as the official medium of exchange and still remained so in 1635; but later in the same century silver pesos of 8 reals became the standard.^(36, 39 and 60)

concluding years of Spanish rule was, of course, detrimental to the mining industry as a whole.

The following tabulation represents an attempt to estimate, on the basis of the data given above, the total gold production of the Philippines prior to the American occupation.

Year	PRODUCTION	
	Annual average	Aggregate
	Kg	Kg
1350-1569	100	22,000
1570-1579	400	4,000
1580-1589	200	2,000
1590-1599	60	600
1600-1609	40	400
1610-1619	30	300
1620-1629	50	500
1630-1639	60	600
1640-1649	70	700
1650-1659	80	800
1660-1669	90	900
1670-1679	100	1,000
1680-1689	120	1,200
1690-1699	140	1,400
1700-1709	160	1,600
1710-1719	180	1,800
1720-1729	200	2,000
1730-1739	220	2,200
1740-1749	260	2,600
1750-1759	320	3,200
1760-1769	450	4,500
1770-1779	400	4,000
1780-1789	380	3,800
1790-1799	350	3,500
1800-1809	350	3,500
1810-1819	350	3,500
1820-1829	300	3,000
1830-1839	250	2,500
1840-1849	250	2,500
1850-1859	200	2,000
1860-1869	150	1,500
1870-1879	125	1,250
1880-1889	100	1,000
1890-1899	50	500

Total 86,650

This total of 80,000 to 90,000 kilograms is the nearest approach to an approximation that the scant existing records permit. It represents the aggregate quantity wrung with crude primitive methods from the auriferous alluvials and quartz veins of the Philippine Islands in the course of five centuries.

As measured with modern standards this quantity is not large, and it is smaller than the aggregate production by modern methods during the present century. It offers a striking contrast to the enormous quantities yielded by the mines and placers of Spanish colonies in America, and unlike the latter it did not contribute to swell the mother country's treasury.

During the three odd centuries that Spanish rule lasted in the New World, Mexico produced the double amount of the yellow metal, Bolivia and Chile each three times, Brazil ten times and Colombia twelve times the output of the Philippines.⁽⁹⁵⁾ Yet in the internal economy of the Islands this gold played a considerable part. During the centuries of the galleon trade it paid for a part of the Oriental—principally Chinese—goods that were imported to Manila for transshipment to Mexico, and it also helped to pay for the commodities needed for domestic consumption.

PRINCIPAL MINING REGIONS

MOUNTAIN PROVINCE

Shortly after their occupation of Manila in 1571 the Spaniards obtained the first vague information from the natives about a rich gold country somewhere in the northern part of the island,⁽¹⁹⁾ in a province called Yloquio, a name easily identified with the present Ilocos. In 1573, Salcedo⁽²⁰⁾ was sent by the government to explore that country. Finding, however, that the gold mines were not situated in the region bordering the coast which he was able to reach, he contented himself with collecting tribute from the inhabitants of the coastal region, dispossessing them of the gold they had obtained in exchange for food sold to the gold digging race living among the inaccessible mountains of the interior.

The first attempt to penetrate into that gold country was made in 1576 at the initiative of Governor Sande⁽³⁰⁾ who sent out a military party, consisting of a sergeant-major with forty arquebusiers. By what route this expedition actually proceeded and how far it penetrated, cannot be ascertained, since the report is distinguished by a total lack of geographical names. It is claimed, however, that it reached the mines, which are described as located in a very rough country, twenty leguas (110 km) inland; that the way thither is obstructed by great forests; that the country is very cold and that it has great pine-forests. He also brought back some samples which

were sent to the viceroy of Mexico. Sande, however, dissuaded from any attempts at exploiting these mines under Spanish management, because of the inaccessibility and barrenness of the region and the hostility of its inhabitants.

Somewhat later several military expeditions were sent to Tuy⁽⁴⁷⁾ or upper Cagayan Valley, to pacify northern Luzon, the route followed thither being up the Rio Grande de Pampanga, through Pampanga and Nueva Ecija, crossing the watershed to Magat. In connection with one of these expeditions governor Gonzalo Ronquillo (governor, 1580-1583) sent Juan Pacheco Maldonado to penetrate into the mountains westward into the gold region; but having wandered about in the wilderness for about two months, allegedly without finding any Indians, his provisions were running low and he had to return without having attained his goal. He is stated to have been a man of "little intelligence."

Somewhat closer geographical directions are given by Pedro Sid, who was sent in 1591 by governor Gomez Perez Dasmariñas⁽⁴⁷⁾ and learned from the natives of Tuy that the gold was obtained from a people called Ygolotes. Since this is obviously a corruption of Igorots, it appears evident that this old gold country is really that of the Baguio region, inhabited by the said tribe. Sid further states that the gold is obtained at Bayaban near Ygyat and Panuypui and Bila, behind a range of mountains. The writer, not being familiar with those mountains and lacking good maps, is unable to identify these names.

In 1594, Luis Perez Dasmariñas, who succeeded his father as governor upon the latter's death,

"sent Captain Clavijo with orders to go on farther in order to discover the mines of the Ygolotes. Although that captain left the province of Tuy in search of Ygolotes he returned back on the way, because he had been assaulted by more than one thousand Indians. The latter wounded his guide, Don Dionizio Capolo, very severely in the face; and it is reported that the captain was forced to return because he had no one to guide him."⁽⁴⁷⁾

It is not until 1609 that we learn from Juan Manuel de Vega,⁽⁴⁷⁾ an official who had been directing the affairs of Tuy, something quite definite about the location of the gold country. He states that

"this region lies between the provinces Cagayan, Ylocos, Pangasinan and Tuy . . . in a district four or five leguas in extent, and included between two large rivers which flow into the province of Pangasinan."

These two rivers can only be the Agno and the Bued rivers, between whose upper reaches lies the Baguio gold mining region with its old Igorot workings.

After all these frustrations there was, however, considerable hesitation on the part of the Spanish officials as regards the exploration of the gold-bearing region. They dreaded to tackle both the deep forests and the lofty, precipitous mountains, giving their valiant inhabitants all the natural advantages in resisting invaders. The Igorots on their part feared "that the Spaniards will go to seek them for their gold and say that they keep the gold better in the earth than in their houses."⁽⁴⁹⁾ They curtailed production in order to attract the least attention. And the Dominican friars who administered the neighboring province of Pangasinan, became their secret allies for humanitarian reasons, "considering the host of vexations, injuries and losses, and the diminution of members that are suffered by the Indians in all the western Indias on account of the labor in the mines."⁽⁵²⁾ To prevent a repetition in the Philippines of these cruelties they "have tried with all their might to cover up this information, on account of this fear that possesses them." And accordingly, for about fifty years after the occupation of Luzon, the Igorots and their mines remained undiscovered, and the government seemed to have settled down to the conviction that they were not worth while to bother about.

But at this time Hernando de Rios Coronel,⁽⁵²⁾ a high official (procurator general) in Manila, had become intensely curious about the Mountain gold. As an ordained priest he had obtained the confidence of several Dominicans from Pangasinan, and the upshot of his inquiries was a memorial to King Felipe III in 1621, in which he strongly recommended a large expedition to explore the region. Although his deductions were built only on hearsay, he wrote with great assurance and with all the authority of his high position, and at the same time most alluringly, about the amazing riches of these mines. Already his introductory sentences give the keynote:

In the Philippine Islands, in so far as I have been able to learn (and I consider it certain), your Majesty has, without going to conquer foreign kingdoms, the greatest wealth which has been found in the Indias.

The bishop of Nova Segovia had certified

"that there was the greatest wealth in the world, and that they had brought him from one hill a little red earth of which the whole hill is composed, which was as much as they could put upon a silver platter. They washed it in his presence and took out seven taes (about 220 gr) of gold, which amount to forty-four castellanos. He asserted that in every part of the hill the earth was all of this richness."

Cautiously enough, however, Rios adds that "even if there were not in these mountains the wealth of which we are told, it seems that the obligation to pacify these Indians exists, and that the holy gospel ought to be preached to them." His alleged scruples regarding the anticipated maltreatment of the natives had been overcome by a lucky idea he had hit upon, viz. to use Chinese labor for developing these mines.

There was at the time at Manila quite a large settlement of this people who were envied and hated because of their superior shrewdness and business acumen and therefore had been harrassed and hampered by all kinds of restrictions and taxes, sometimes even actively persecuted.⁽⁸⁹⁾ Accordingly, many of them had difficulties in earning their livelihood. So the worthy official had arrived at the conviction that

"the same reasons did not hold there (in the P.I.) as in Nueva España (Mexico) and Piru (Peru), for ill-treating the Indians; for there are so many Chinese who are raising their hands to God to find something to work at—as many as necessary."

This rather curious argument had also converted the religious to his point of view, so that they had become willing unreservedly to furnish him with information.

No wonder that this powerful appeal, alike to the avarice and to the civilizatory duties of the king, had the desired effect. In a letter dated Madrid, October 9, 1623, king Felipe IV, who had in the same year succeeded his deceased father, instructed⁽⁵³⁾ the governor of the Islands, Fajardo de Tenza, to carry out the exploration of this "Eldorado." In pursuance of the royal command an expedition was fitted out at Manila under the leadership of sergeant-major Alonso Martin de Quirante.⁽⁵⁵⁾ It was quite an imposing expedition, for as finally organized at the port of Aringay in Pangasinan, it consisted of 70 regular Spanish soldiers and officers of his company, 14 adventurers ("extravagantes") as substitutes, 2 sailors (one of them a miner), 2 Japanese miners, 1 armorer,

1 clerk, 1 notary, 11 of his Majesty's negro slaves (galley-slaves), 9 Indians (Filipinos imprisoned for crimes), 47 "Sangley"⁶ carpenters, smiths, sawyers, and 1,748 other Indians (Filipinos), of which 893 men from Ilocos were formed into twelve companies, and 855 men from Pangasinan were formed into ten companies. Finally, there were two religious fathers to act as the "curas and vicars for the success of the said expedition."

After a general muster at Aringay on February 14, 1624, Quirante on the 16th dispatched an advance party consisting of 200 soldiers and 200 Indians with light equipment, to clear the way and to establish camping places, whereupon the main force, divided in three parties, started successively with a day's interval, Quirante himself with the last division starting on February 19. The route taken by the expedition is not sufficiently clearly indicated, but probably the trail Tubao-Puga-Tuba, north of Mount Sto. Tomas, was followed up towards the Baguio region. On the 22th the whole expedition was again united at a place called Buena Vista, where stockade forts erected by the Igorots were encountered at a narrow defile. These were taken by storm on the next day by Quirante with 30 soldiers. The resistance of the natives was suprisingly weak; probably they were overawed by the numbers and firearms of the invaders. On the 24th the entire expedition passed on, arriving after two day's march at "the new mines called Galan, about three leguas (17 km) from Rio Frio," where 200 houses—abandoned by their occupants who had all fled lay scattered among the hills. Here, in a dominant position, the Spaniards started building a fort which they called Santiago.

On February 28th Quirante sent back most of the Filipinos, retaining only 200 natives from Pangasinan and Ilocos, as well as the Sangleys and prisoners. His orders were that the party sent to Aringay should bring back three months' provisions. On March 24 he mustered all the remaining men, paid off and despatched most of them, keeping only some of his soldiers, 120 Filipinos from both provinces, 31 Sangleys and 5 extravagantes. The lieutenant in command of the

⁶ Corruption of the Chinese "shang lei," meaning itinerant merchant. This term was commonly used in the Philippines as a synonym for Chinese.

departing party was ordered to send up on May 15th 400 other natives from Pangasinan and 100 ones from Ilocos, all laden with provisions and other necessities. Having done this, Quirante devoted himself exclusively to the gold mines.

For that purpose I immediately ordered Martin de Vergara, my alferéz Rodrigo Lopez Orduña, Juan Mugaburu, Graviel Molinero, and Diego de Tovar, soldiers of my company and all miners, and other persons who understood something (of mines) to investigate and reconnoiter.

The description given of the various mines, however, is confused and hazy, and therefore difficult to get either head or tail of.

However, it may be gathered from the report that the natives—besides extracting gold from the gravel of the stream-beds during the rainy season—were carrying on mining in five different localities. The approximate distances between these places are estimated, but no points of the compass indicating their mutual situation are given. Since, moreover, most of the names are unrecognizable at least to one not intimately familiar with the geography of the region, the writer is unable to identify them, except the Antamok mine which today still is known under the same name. These are the five places mentioned; Galan or new mines, uppermost; Arisey or Bugayona, three leguas (16 km) from Galan; Baranaban 1 legua (5.5 km) from Arisey; Antamog 2 leguas (11 km) from Arisey and $5\frac{1}{2}$ leguas (30 km) from Galan; Conog $\frac{1}{2}$ legua (2.8 km) from Antamog.

The mine of Galan is described as situated

"in the northern part (of the ridge) and extends from above downward in the manner of a horizontal vein or shell for the distance of a musket-shot from northwest to southwest and then twists about for another equal distance to the direction that looks toward the northwest and east, until it disappears into the depths of a ravine."

At the time of the arrival of the Spaniards

"the Ygolotes were working at the said mines through many mouths or passages that they had opened, following the metal of one large vein, from which they were taking out the ore that was softest and easiest to dig, although it contained blue iron pyrites that contain antimony."

The Spaniards opened a new shaft (or adit) in the center of the old mine and took out a considerable amount of ore for sampling and assaying.

The workings at Arisey⁷ are described rather obscurely as situated on a slope facing west and have "a descent of one half legua that is very troublesome as it is very steep with two divisions of ravines at the side and precipices along both slopes and also in front." There is "a slope which is at the foot of the work where the natives washed (gold) and gathered certain small stones known to them which they crushed for their profit." No solid vein was found here; only loose "dirt," and the old workings had all collapsed. At the mouths of the latter some ore was obtained for assaying.

At Baranaban, on a barren hill facing south, there "runs a vein about one vara (0.8 m) wide, extending east and west for some distance. There are some works and openings there, narrow and distinct one from the other. Thence were taken fifteen baskets of gravel and dirt, which has the color of coal." This description refers to the black manganiferous ore which is quite common in the Baguio region.

The Antamog mine is stated to be situated facing south from a large hill and

"traversed by very narrow small threads (stringers) of white and yellow metal while all the elevation is traversed by and filled with passages, which are found intermixed, opened sidewise from the vertical and inward, and dipping downward scarcely at all, as the threads of the metal are not deep. In order that these may not cave in, they are propped up with stakes and boards. From the said threads they obtained a kind of brass-colored and less dirty earth, (?) in order to wash it at another large placer that they had at one side of the said elevation."

Twenty baskets of ore were taken from here for sampling and assaying.

The last of the above mentioned places, Conog, is said to be

"located in the same chain. The said elevation, turning, extends towards the north. In it are to be seen five or six openings or passages, that differ but little from those of Antamog. No considerable or fundamental vein was found, but only brass-colored earth that contained some small bits of blue metal containing iron pyrites, all of them very soft."

Ten baskets of ore were collected here.

Quirante remained at the mines till the end of May and when leaving carried with him 100 quintals (4,600 kg) of

⁷ Quirante here makes an enigmatic statement about an old fort called Del Rosario, situated at this place which had been "destroyed by fire in November of the past year.

ore samples. At Fort Santiago he left a garrison of 56 Spaniards, 50 Filipinos (25 Pangasinan men and 25 Ilocos men), the 11 galley-negros and one armorer, provided with food and supplies for 15 months.

Quirante's general impression of all these gold deposits was not favorable. About the alluvial gold extraction he writes:

In the rainy season, that wretched race (which he elsewhere describes as bold, well-built and active) most of whom are miners, unite with their wives and children to wash the sand of the streamlets that flow from the mountains, where with less work than in their mines, by avoiding the digging and crushing, they get some gold, although very little.

Of the profit derived from mining he also has a very low opinion:

" . . . those Ygolotes are indebted to the natives of the villages who are our friends, and are unable to pay those who give them credit, the wealth and wit of both peoples being so small and restricted that, although those people have no other kind of expenses, or other thing to attend to, than the product of their mines, they are very generally in debt—sure proof of the mistake made in believing that the gain is much, or the said mines of much importance, as has been demonstrated by experience."

These pessimistic inferences and misgivings of Quirante were fully borne out by the assays, of which a first series was made on the spot.⁽⁵⁵⁾ For extracting the gold from the samples amalgamation was used, the amount of mercury added to the crushed ore being as a rule at the rate of 1 lb of mercury to each quintal of ore, or about 1 per cent. The size of the individual samples usually varied from 1 to 3 quintals and the fineness of the gold regulus obtained ranged from 14 to 22 carats. These assays, with the values recalculated as grams of pure gold per metric ton, are given in the following tabulation:

Galan	18.5	Barnaban	11.9
Galan 17 m depth	5.1	Arisey	6.1
Galan	4.6	Antamog	3.2
Galan	236.0	Conog	3.2
Galan 17 m depth	18.0	Galan, near Santiago	nil
Galan 19 m depth	33.2	Galan	12.2
Galan washing place	59.0	Galan, near Santiago	17.0
Galan vein	10.6	Galan western part	nil
Galan cont. Sb	8.7	Galan	24.8
		Galan first hole	4.7

The average of these assays is about 22 grams per metric ton, equivalent to about P26.00 per short ton, a tenor which, incidentally, comes very close to that of the Benguet ore mined and milled today. Such a comparison, however, would be misleading. On the one hand, Quirante's assays were no doubt very much lower than the true values in his ores, because a considerable portion of the gold is not extracted by amalgamation. On the other hand, most of the samples probably represented picked or washed ore, higher than the average. Of the values actually contained in the ore mined and extracted by the Igorots at that period, these analyses, therefore, give only a rough idea. At any rate these assays, as well as the other facts reported by Quirante, proved a grievous disappointment to the Spanish authorities. For not only were the values far below the extravagant expectations aroused by Rios Coronel's fancy tales: they were even below the limit of profitable extraction, as practiced by the Spanish miners of those days, particularly in a remote and inhospitable region. At a council held in Manila on July 13, about a month after Quirante's return,⁽⁵⁵⁾ it was decided to send all the samples to Mexico, for checking the assays made at the mines. There even seems to have lingered a hope that the poor values obtained so far were due not to the poverty of the samples themselves, but to the lack of ability on the part of the assayers. For in the minutes of the said meeting it is stated that in Mexico, where

"there are many persons skilled in mines and assay of ores . . . they might be able to furnish the accurate tests that had not been arrived at here. If they did not succeed in ascertaining its quality there, that would be a great proof of the disillusion talked of here."

The same ideas are also implied in a letter from Governor Fajardo to the King, dated August 17⁸ in which he notifies the latter of the results of the expedition:⁽⁵⁴⁾

The indications of the mines, the disposition of the ridges and the quality of the earth where they are, promise more richness than do the trials which have been made thus far by washing and separating the gold. Until all the tests which are used for this purpose have been made, it cannot be certainly said what the value will be, although it appears to me that cannot be small, considering the large amount of gold which the natives take from the mines and barter with the friendly Indias.

⁸ In Blair & Robertson the year is stated to be 1628, but the events referred to in the letter prove that it was written in 1624.

At the said conference in Manila it was, furthermore, voted that the expenses for opening up the mines be curtailed and that the garrison of Fort Santiago be withdrawn. This was done, for in a letter to the king, dated August 4, 1625, the Acting Governor Fernando de Silva⁽⁵⁶⁾ reports:

Your Majesty orders me to advice you of the mines of the Ygolotes. . . . More than fifty thousand pesos were spent in the mines, but nothing was found at last. A quantity of rocks were sent to Nueva España in order to be assayed there, as we had no one here, who understood it, and the soldiers having been withdrawn, that exploration was abandoned, as a matter of fact that did not have the desired result.

So the king had to accept the failure and in a letter to Governor Juan Niño de Tavora, dated November 21, 1625, the latter was instructed to handle the question of further attempts as he saw fit. And there the matter was dropped. Was ever a fiasco more complete and more mortifying?

Yet only twelve years later, in 1637, all the adverse experiences seem completely forgotten, for in that year the Procurator General Don Juan Grau y Monfalcon⁽⁶⁰⁾ memorialized the king about "persistent rumors regarding the Pangasinan hills, which are forty leguas (220 km) away from Manila, namely that they are full of gold."

No further attempts to solve the mystery of the Mountain gold were made, however, until 1668, when Governor Diego de Salcedo sent an expedition for the christening and conquest of the Igorot country.⁽⁶⁵⁾ Admiral Pedro Duran de Monforte was appointed commander, and several priests accompanied the expedition. Although they had considerable success in converting and subjugating the Igorots, their efforts to discover any rich gold deposits in that region were as futile as before.

Casimiro Diaz⁽⁶⁵⁾ thus describes the results arrived at:

The Spaniards did not neglect to look for gold mines, for the working of which they took along miners and plenty of tools. But although they found mines in the latitude of 17 degrees, from which the Igorots extract very fine gold, our miners could not obtain any in all the assays that they made, for all went up in smoke.

This meant

"frustration of all the hopes for the rich gold mines which so incited greed; for all those who went on that expedition were boasting that they were already Croesuses and Midases. It is certain that the Igolotes get the great quantities of gold which they have brought down to sell in the provinces of Ilocos and Pangasinan; but it appears that divine

wisdom does not choose that they should fall into our hands, for it was very certain that we would make an ill use of that benefit."

Again the same results: no deposits rich enough to yield attractive profit—and the Spaniards had to acknowledge tacitly the superiority of the Igorots—under existing conditions—as miners and metallurgists.

This was evidently the last organized attempt of the Spaniards to exploit the Mountain gold for their own benefit. Henceforth the Igorots were left in undisturbed possession of it, and they went on with their gold mining as before. A century after Diaz' expedition, in 1765, Viana(70) mentions this region as still being the chief gold producer in the Islands. After that time this mining center seems to have received little attention from the authorities; it appears that the output declined, as the mines were becoming too deep for convenient unwatering without mechanical installations.

It was not until the first years of the present century that, under American auspices, operations on a modern scale were started in this region which is now the most prosperous gold center of the archipelago.

PARACALE-MAMBULAO

The Paracale-Mambulao region in Camarines Norte is the only gold field in the Islands where the Spaniards made persistent attempts to organize and keep up production.

Exactly for how long a time prior to the arrival of the Spanish conquerors the placers and mines of Camarines had been worked by the natives cannot be established; but located close to tide water and conveniently reached from the Visayan center of the archipelago through San Bernardino Strait, they must have been discovered early enough when the gold cult spread over the Islands. When Legaspi started to explore the Visayas, the Chinese had already a well established and regular trade connection with Camarines, whither they came every year, as mentioned by Rada(17) in 1569, and the Spaniards found both placer and lode mining carried on to a considerable extent.

Shortly after Legaspi's occupation of Manila, in 1571, one of his exploring parties under Juan de Salcedo,(19) in making a raid east of Laguna de Bay, learned from the inhabitants about the existence of gold mines somewhere farther east.

Promptly he decided to march thither right across the country. He

"crossed with sixty men to the opposite coast of the island, in quest of some mines which the natives had told him were very rich and abounding in gold. These mines are on the opposite coast of this island, which is the northeastern, and the natives call them the mines of Paracale. When the captain had arrived at the mine with his soldiers, who had suffered much from the march, because it was in the wet season, they found them excellent and very rich, and more than thirty or forty estados (50-70 m) in depth. The natives were afraid and did not await the coming of the Spaniards. Some of the soldiers complained that the captain conducted himself badly. And thus they returned having lost by death of four soldiers . . ."

Some more details about this expedition have already been told (cf. footnote on p. 559).

Even if the depth of the mines as stated above, has been much exaggerated, and very likely refers to the length of the tunnels which the Spanish soldiers never measured, it is beyond doubt that lode mining had been in progress for a considerable space of time.

To what extent the Spaniards took the initiative in developing gold mining does not appear clearly from available documents. It is evident, however, that the gold production from both placers and mines continued, probably under the direction of Spanish overseers. Mirandaola,⁽²⁵⁾ in 1574, mentions "gold mines in Paracale and a river near by from which fine gold is taken." The Spanish galleons, coming from Mexico twice a year, made this place a port of call, and from that country also a notable improvement in the crushing of the ore—the *arrastre*—was introduced (cf. p. 570). Yet here as elsewhere there was a tendency to decline, because the natives preferred to pay the tribute in money. In a report (50) from 1617-1620 it is stated:

It is believed that as much gold is made now as usually, yet it seems a small quantity, for although the Indians in general have more money than formerly, they keep back the gold to work up into chains and jewelry with which they adorn and parade themselves freely.

Instead, they paid their tribute in tin reals.

In 1626, the *alferez* (ensign) Don Diego de Espina discovered the "vena grande" on mount Calacot (?) which was probably identical with the main vein of San Mauricio near Mambulao.⁽⁸²⁾ In order to induce the natives to develop this new vein and instil the necessary sense of security, a royal

decree was issued, dated September 22, 1636, instructing the said alferez (who was probably in command of the local garrison) to safeguard their rights.

What effect this decree may have had, we do not know: but in a report written by a Franciscan friar⁽⁶²⁾ in 1649 it is stated regarding this district:

Mines fill up immediately with water and hence they have no importance to Spaniards. But the Indians, who are plodding and work little by little, get a sufficient quantity.

The yield, on the whole, must have been good, for in 1662 Letona⁽⁶³⁾ states that there are some rich gold mines in Camarines.

In 1701 Don Nicolas Araerjo de Troncoso and Don José Rojo de Brione became interested in the gold mines and had some work done at Mambulao,⁽⁸²⁾ but nothing is recorded about the outcome of their venture.

In 1775 Don Francisco Estorga lost a large portion of his fortune in the same mines, but he was fortunate enough to recover his losses by developing a new mine at Paracale, so that he could comfortably retire to Spain.⁽⁷⁵⁾

The Frenchman Felix Renoard de Sainte Croix, who examined the Mambulao gold mines in 1805, is stated to have "explained in his report that various gold mines existed there, with very rich veins, but some were difficult to develop and others had been abandoned." Another Frenchman, J. Mallat,⁽⁹²⁾ who visited this region about 1840, found only one mine in operation at Paracale, at Mount Bagacay, and his statement that "la mine de Mambulao fournit des sables aurifères, qu'on lave," seems to indicate that lode mining was then at a low ebb in this district, only the placers being worked.

An attempt to carry out an extensive drainage scheme at the Mambulao mines was made a few decades later by Don Manuel Moreno, who in 1848 founded the Ancla de Oro Company.⁽⁸²⁾ A drainage tunnel just to the north of Mambulao town and close to sea-level was started, evidently with the object of reaching the veins under the bottoms of the old workings. But the country-rock, an extremely hard and tough pyroxenite, apparently proved too much to tackle with blunt drills and black powder, and the project had to be abandoned after the adit had been pushed only some fifty

meters into the hillside. What other development work this enterprise may have carried out, is not known, but its efforts failed and the company was dissolved in 1859.

When the German explorer Feodor Jagor⁽⁸⁹⁾ shortly afterwards, 1859-1860, visited this district, he saw only desultory work carried on by the natives who lived in miserable huts and went about almost naked. Laboring most of the time in water up to their waist, they succeeded in extracting a mere pittance of 1 to 1½ reals (12 to 19 centavos) a day. But, again, his countryman, the noted geologist Richard von Drasche⁽⁷⁸⁾ who travelled in Luzon during the following decade (1870-1880), describes extensive native work in progress at Dagupan, southwest of Mambulao. At the time of his visit there he saw about 700 men and women busy sinking a great number of small shafts down to a depth of some 15 fathoms, especially in such places where quartz stringers were visible on the surface. The output, however, seems to have been small, as Centeno⁽⁸³⁾ reported in 1876 that the production of Camarines amounted to only 30 Spanish ounces (865 gr) a month.

The next attempt at a resuscitation of lode mining in this region, the last one during the Spanish regime, was started in 1893 by a British company, the Philippine Syndicate, Ltd.⁽⁹⁹⁾ This company acquired from the Spanish Crown extensive mining concessions embracing not only the San Mauricio group of mines, but also most of the other gold occurrences in the Paracale-Mambulao region. Mining on a large scale was contemplated, with modern mechanical machinery and recent improvements in ore dressing and metallurgy. Exploration and development work was started at several of San Mauricio mines, at Longos near Paracale, where a stamp mill was erected and at Tumbaga south of Mambulao, where a Huntington mill was installed. At San Mauricio this company made development work in the main mine, from the tunnel driven from Calupcup valley, as well as further north from the "granite tunnel" connecting with the Dona Panay workings, and in a third tunnel still further north. But the company had not reached the producing stage when the Filipino insurrection broke out in 1896, bringing all the activities of the company to an abrupt standstill.

Disturbed condition also prevailed during the following year, and in 1898 the Spanish-American war brought renewed hos-

tilities to the Islands, the aftermath of which lasted for several years, until in 1902 the American military administration finally restored order throughout the archipelago. But the company was not minded to go ahead any longer. However, it may be taken for granted that even had there been no sudden interruption of the company's preparation this enterprise would have been doomed to failure. For the ores were only partly free-milling and even amalgamation did not extract more than at best half of the gold contents of the ore. The cyanidation methods had not yet been developed at that time.

It should be added that, simultaneously with the activities of the British Syndicate, a first attempt was made to dredge the auriferous sands of the river mouths of the region. In 1896, a syndicate of Manila Spaniards constructed a small primitive bucket dredge and put it to work in the Paracale River.⁽⁸⁸⁾ This attempt was a forerunner of the successful dredging operations that were started about a decade later. Judged by today's standards this dredge was indeed a Lilliputian. Its capacity could not have been over 15 cu m; it could dredge only to a depth of 2.7 m, and it could not wash the dirt excavated.

Before concluding this account of the history of the Paracale-Mambulao region, some stories of local tradition, of which I have found no mention in the official documents, may be briefly referred to. To what time or period these stories belong is not known, but it seems likely that they date from the 17th or 18th century. One of the magnates of the palmy days is said to have been one Señor Calupcup, after whom the creek draining the San Mauricio area has been named. He is said to have paid for all of his purchases in gold dust from his mines. Another romantic person of tradition is a lady, Doña Panay, whose name is also perpetuated by some of the workings, reputed to have been extremely rich. It is told of her that when asking protection from the Spanish Crown against the raids of Moro pirates, she had a life-sized hen and a setting of eggs made of solid gold which she sent to the queen of Spain with her petition. On a hill above the Ancla de Oro adit are the ruins of a small fort which is said to have been erected in response to Doña Panay's supplication.

As an indication of the intensity and thoroughness with which the search for the yellow metal has been going on in this region, may be mentioned the many hundreds of caves in

test pits and tunnels are scattered all over the gold-bearing area. They practically cover the accessible portions of the veins which have mined out as deep as the workings could be drained by primitive methods. There must have been a large force of native miners, probably financed, directed and organized by Spaniards or wealthy mestizos. Local tradition puts the erstwhile number of population in the municipality of Mambulao at from 30,000 to 60,000. However, even the former figure appears to be an exaggeration, although rough stone basements of ancient houses are found widely scattered in the jungle, outside the present settlements, mainly along the Calupcup Creek valley. Reliable figures for the early times are lacking, but Buzeta and Bravo⁽⁸¹⁾ give statistics for 1829 and 1846. In the former year Mambulao had 2,811 and Paracale 3,504 inhabitants; in 1846 the corresponding figures were 4,428 and 5,488.

MASBATE

The placer workings and mines of Masbate are no doubt among the oldest in the Philippines; it is claimed that fragments of pottery older than the Chinese Ming dynasty (1368-1644) have been found near the ancient tunnels and open-cuts.⁽¹⁰¹⁾ On their foraying expeditions northward from Cebu—where they established their first headquarters—the Spaniards hit upon these mines, the first ones of importance they had found. Rada⁽¹⁷⁾ reports in 1569 that Masbate has many gold mines, and Artieda⁽²³⁾ in 1573 states that they are from two to four *estados* deep (3.5 to 7.0 m), "somewhat more or less, although I have not measured them. I understand that the mines yield very little on account of the scanty mining population, and its trade is of slight value." Loarca⁽³⁴⁾ in 1582 estimates the population at about 500. The placers, too, seem to have been worked, for Mirandaola⁽²⁵⁾ in 1574 mentioning Masbate, states that gold is taken from the rivers. Herrera⁽²²⁾ in 1573 calls Masbate the chief gold mines of the country, and Loarca reports that they had formerly yielded much gold, "for the natives of Camarines went thither to work them, but they have left the place on account of the Spaniards and therefore the mines are not worked." Hence, here as elsewhere, the early Spaniards with their depredations did more to discourage and destroy the mining industry of the natives, than to promote it.

The item regarding the connection with Camarines is interesting; considering the difficulties experienced in the latter place on account of water during the rainy season, it seems probable that the miners used to set sail for Masbate to take advantage of the dry season there. Juan de Vega⁽⁴⁷⁾ writing in 1609, mentions these mines as still productive, but Pedro de Assis⁽⁶⁷⁾ reports about fifty years later that "their working has not been continued, either for lack of people suitable for this work, or for other reasons," and he explains further that when the Spaniards "tried later to work them, it was found (that the mines) did not produce expenses."

At Masbate, as in Mountain province, the Spaniards experienced disappointment; their methods were less efficient and more expensive than those of the natives. The Masbate mines remained abandoned for more than three centuries—save for some desultory attempts—until early in the 20th century they were again taken up under American auspices.

OTHER GOLD REGIONS

Among the Philippine gold regions, both placers and lodes, there seem to have been few that were not known and worked in a primitive fashion already in early Spanish, or even pre-Spanish time. For besides the many localities that are mentioned in the reports of the early writers, there must have been a still greater number of deposits omitted, because Spaniards had never seen them or heard of them. However, apart from the three principal gold regions dealt with above, gold deposits are recorded by the early writers in all parts of the archipelago, although the localities are not always described in enough detail to permit identification.

Mindanao.—Already Pigafetta⁽³⁾ claims that gold was the most abundant product of this island, and describes how at Quipit on the north coast the natives

"showed me certain large valleys, making me a sign that the gold there was as abundant as the hairs on their heads, but they had no iron with which to dig it and they do not care to go to the trouble."

Transylvanus,⁽⁵⁾ also reporting on Magellan's expedition mentions the same place as abounding in gold. Loaisa and Villalobos^(6,8) report gold, the latter particularly mentioning Butuan in the same region (Agusan). So does Legaspi and others^(9,19) in 1570 pointing out the country between Butuan and Cape Calamite as particularly rich.

But Artieda,(23) who had been sent there to explore, in 1573 reported that

"the northern promontory juts out between the two rivers Butuan (Agusan) and Zurigan (Surigao), famous for their gold, although the Spaniards who went there were able to find but little—or to be more accurate, none. According to what I have learned, all the gold mines of this island are poor."

Again Mirandaola(25) gives a favorable opinion of the above district; Artieda, according to our present knowledge, was somewhat too pessimistic. Mirandaola also adds the Parasao region as gold-bearing. The placers of Tirurei River (Cotabato) were known in 1576.(33)

Loarca,(34) in 1582 points out that there were gold placers and mines all over the island "but in so small quantity that it can hardly be detected." Placers in Siargao Island (Surigao) are also mentioned by him, and those on the Vermeja Island close to Surigao and on Samal in Davao Gulf are referred to by Herrera(22) already in 1573. Both Dasmariñas(40) in 1591 and Morga(49) in 1609 claim that Mindanao is rich in gold.

Dampier,(66) at the end of the 17th century, reports that the "Ilanos in the heart of the island enjoy the benefit of the gold mines, and with their gold buy foreign commodities." And in Dalrymple's days,(69) in 1762, Butuan is said to have yielded much gold.

Bowring(80) in 1859 stated that the Caraga Mountains (Davao) were productive and Minard(93) in the seventies mentioned Surigao and particularly the Pigtao region (Misamis).

Somewhat later Europeans were active in the Cansuran district in the center of the peninsula of Surigao.(84)

Visayas.—Cebu figures in some of the early reports as an important gold region,(6,12) while in other(34) it is stated that the island lacks both gold mines and placers. Morga(49) refers to the Taribon mine as being worked, and both Dalrymple,(69) Bowring,(80) and Buzeta and Bravo(81) mention it as gold-bearing and productive. Other regions in the Visayas are also referred to, such as Arevalo in Panay, Bohol (Chirino,(46)). Already Pigafetta records gold extraction in Limasaua, south of Leyte, and Dalrymple claims that Maripipi north of Leyte has also plenty of gold. During the northward progress of the exploratory expeditions sent out by Legaspi from his

headquarters at Cebu, Mindoro was discovered to be gold producing, (14, 15, 19) but later this island is not mentioned.

Luzon.—Besides the principal regions described in the foregoing, various other occurrences receive early mention in the reports, such as Patso, (?) (Bontoc ?), Pacorago(?) and Malabago (Maribago?) by Herrera⁽²²⁾ in 1573 and Mirandaola⁽²⁵⁾ in 1574.

Loarca⁽³⁴⁾ in 1583 claims that all the land between Tuley (Tuy, Nueva Viscaya) and Batangas possess much gold, and that there are gold mines at Lobo and Maribago east of Batangas town.

Among later writers, Letona⁽⁶³⁾ in 1662 mentions gold in Pampanga, and Bowring⁽⁸⁰⁾ in 1859 states that a company by name of Sociedad Exploradora was then engaged in working gold mines and washing auriferous sands in Nueva Ecija. Buzeta and Bravo draw attention to the Gapan region of the same province as containing the purest gold in the islands. Bowring states, furthermore, that the most remarkable and profitable of all the gold mines worked by the Indians are those of Tulbin (?) and Suyuc (Suyoc).

Catanduanes Island off the southeast coast of Luzon was visited already by Salcedo,⁽²⁸⁾ and the gold mines there are referred to by Loarca⁽³⁴⁾ as being worked by the inhabitants of Vicor (Bicol) River (Camarines Sur), and the same deposits are also mentioned by Vega.⁽⁴⁷⁾

APPENDIX

WEIGHTS, MEASURES AND CURRENCY

The weights and measures current in the Philippines during Spanish time were of twofold origin, viz. Indian and Spanish. Malay immigrants, already centuries before the advent of the Spaniards, had introduced the former, and many of them continued in use throughout the Spanish era, such as the pico, the cate, the tae, etc, which, by the way, have been adopted throughout the Far East. Castilian weights, measures and money were naturally introduced by the Spaniards. The following conversion table does not pretend to be exact, since the equivalents computed from different sources are often considerably at variance. For example, the common gold weight, the tae, is variously stated to be equivalent to $1\frac{1}{2}$ and $1\frac{1}{4}$ Castilian ounces and 10 reals, corresponding to

respectively 31.1, 34.5 and 33.4 grams, while the Chinese tael is 37.9 grams. For various reasons the writer believes the first equivalent to come nearest to the truth. The gold-silver ratio at different periods is required for computing the quantities of gold corresponding to values of production as given in silver currency, and a separate table containing these data has, therefore, been compiled. The European ratios were taken from⁽⁹⁵⁾ the Chinese ones from Pierre Hoang, *La propriété en Chine*; and the Philippine ratios from^(10, 70, and 80).

Length

- 1 estado or braza = 2 varas = 1.7 meters
- 1 vara = 0.85 meter
- 1 legua = about 5.5 kilometers

Capacity

- 1 fanega = 3 barchillas = 55 liters
- 1 barchilla = 18.3 liters
- 1 ganta = 3 liters

Weights and currency

- 1 cate = 550 grams
- 1 pico = 55 kilograms
- 1 tac = 10 maes = 31 grams
- 1 mae = 10 condareens = 3.1 grams
- 1 quintal = 8 arrobas = 46 kilograms
- 1 arroba = 5.75 kilograms
- 1 libra = marcos = 442 grams
- 1 marco = 8 onzas = 221 grams
- 1 onza = 27.6 grams
- 1 real = 3.37 grams
- 1 ducado = 10 reals = 33.7 grams
- 1 peso oro (gold) = about 4 grams
- 1 castellano = about 5 grams
- 1 peso duro (pillar dollar, silver) = 8 reals = 27 grams of silver, about 900 fine

Gold: silver ratios

EUROPE		CHINA		PHILIPPINES
1493-1560	1:11	about 1380	1:4	1565 1:6
1561-1620	1:12	1573-1619	1:7	
1621-1660	1:14	about 1640	1:6	
1661-1875	1:16	1662-1722	1:11	
1876-1885	1:18	1736-1795	1:20	1765 1:14
1886-1890	1:21	about 1840	1:18	
1891-1895	1:27	do 1850	1:14	
1896-1900	1:33	1882-1883	1:18	1859 1:12

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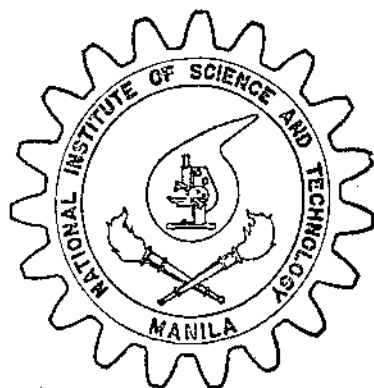
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